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IN THE

SUPREME COURT OF THE UNITED STATES

OCTOBER TERM 1997

KUMHO TIRE COMPANY, LTD., *et al.*,

Petitioners,

v.

PATRICK CARMICHAEL, *et al.*,

Respondents.

On Writ of Certiorari to the United States Court of Appeals for the Eleventh Circuit

BRIEF FOR JOHN ALLEN, GREGORY BAECHER, EDWARD BOUWER, EVERETT CARTER, STEPHEN DIRECTOR, RICHARD MEEHAN, GENE PARKIN, BRUCE RITTMAN, YARON STERNBERG, DONALD VANNOY, DAVID WAGGER, CHRISTOPHER WILT, AND GORDON WOLMAN AS *AMICI CURIAE* IN SUPPORT OF PETITIONERS

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August 25, 1998

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QUESTIONS PRESENTED

Amici curiae address two questions, both of which are elements of the question presented by Petitioners in their petition for *certiorari:*

(1) Whether a trial judge, in deciding whether to admit expert engineering testimony under Rule 702 of the Federal Rules of Evidence, should be required to make a preliminary assessment that the reasoning or methodology underlying the testimony (a) is scientifically valid or reliable and (b) can be applied to the facts at issue well enough to assist the jury.

(2) Whether a trial judge, in making this threshold assessment, should consider the four factors identified by this Court in *Daubert* v. *Merrill Dow Pharmaceuticals, Inc.*, 509 U.S. 579 (1993).

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TABLE OF AUTHORITIES

Cases

Carmichael v. Samyang Tires, Inc., 923 F. Supp. 1514 (S.D. Ala. 1996) 18

Carmichael v. Samyang Tires, Inc., 131 F.3d 1433 (11th Cir. 1997) 15, 17, 18, 19, 20, 21

Compton v. Subaru of America, Inc., 82 F.3d 1513 (10th Cir. 1996) 15, 19

Cummins v. Lyle Industries, Inc., 93 F.3d 362 (7th Cir. 1996) 27, 28, 29

Daubert v. Merrell Dow Pharmaceuticals, Inc., 509 U.S. 579 (1993) ..... *passim*

Daubert v. Merrell Dow Pharmaceuticals, Inc., 43 F.3d 1311 (9th Cir. 1995) 16, 17

Diviero v. Uniroyal Goodrich Tire Co., 919 F. Supp. 1353 (D. Ariz. 1996), *aff'd*, 114 F.3d 851 (9th Cir. 1997) 11, 19

Duffee v. Thornton, 879 F. Supp. 1078 (D. Kan. 1995) 28

General Electric Co. v. Joiner, 118 S. Ct. 512 (1997) 5, 15, 29

Guillory v. Domtar Industries Inc., 95 F.3d 1320 (5th Cir. 1996) 14, 26, 27

Habecker v. Clark Equipment Co., 36 F.3d 278 (3d Cir. 1994) 26

Hewitt v. B.F. Goodrich Co., 732 F.2d 1554 (11th Cir. 1984) 11

McKendall v. Crown Control Corp., 122 F.3d 803 (9th Cir. 1997) 15, 19

Michigan Millers Mut. Ins. Corp. v. Benfield, 140 F.3d 915 (11th Cir. 1998) 17

Pestel v. Vermeer Mfg. Co., 64 F.3d 382 (8th Cir. 1995) 27

Pomella v. Regency Coach Lines, Ltd., 899 F. Supp. 335 (D. Mich. 1995) 26

Smelser v. Norfolk Southern Ry. Co., 105 F.3d 299 (6th Cir. 1977) 14, 25, 26

Tyus v. Urban Search Management, 102 F.3d 256 (7th Cir. 1996) 14

Watkins v. Telsmith, Inc., 121 F.3d 984 (5th Cir. 1997) 14, 17, 27, 28, 29

Williams v. Michelin Tire Corp., 496 So.2d 743 (Ala. 1986) 11

Regulations and Rules

10 C.F.R. Part 473 10

Fed. R. Civ. P. 11 21

Fed. R. Evid. 102 11

Fed. R. Evid. 201 19

Fed. R. Evid. 702 ..... 3, 4, 13, 15, 16, 22

Other Authorities

American Society for Testing and Materials, *Annual Book of ASTM Standards* (1996) 25

J. Ambrosio, *et al.*, eds., *Crashworthiness of Transportation Systems: Structural impact and Occupant Protection* (1996) 10

A. H-S. Ang, *et al.*, eds., *Structural Safety and Reliability: Proceedings of ICOSSAR '89, The 5th Annual Int'l. Conf. on Structural Safety and Reliability* (1989) 10

J.E. Bernard & C.L. Clover, *Validation of Computer Simulations of Vehicle Dynamics*, SAE Paper No. 940231 (1994) 24

R.L. Brent, "Benediction: Review of the Medical Literature of a Comprehensively Studied Human Nonteratogen and the Most Prevalent Tortogen-Litigen," 9 *Reproductive Toxicology* (1995) 15

P.S. Bulson, ed., *Structures Under Shock and Impact II: Proceedings of the Second International Conference* (1992) 10

J. Collins, *Failure of Materials in Mechanical Design: Analysis, Prediction, Prevention* (2d ed. 1993) 8, 29

T.D. Day & R.L. Hargens, *Application and Misapplication of Computer Programs For Accident Reconstruction*, SAE Paper No. 890738 (Feb. 27-Mar. 3, 1989) 25

M. [illegible]nn, *The Identity of Our Profession*, in *Advances in Chemical Engineering: Perspectives in Chemical Engineering, Research and Education* 567 (1991) 9

A. Ertas & J. Jones, *The Engineering Process* (2d ed. 1996) 12, 29

C.W. Fetter, *Contaminant Hydrogeology* (1993) 12

K. Foster & P. Huber, *Judging Science: Scientific Knowledge and the Federal Courts* (1997) 16

Frumer & Friedman, *Products Liability* (1998) 23, 27

http://www.engin.brown.edu/Academics/Philosophy.html 9

http://www.jhu.edu/~admis/catalog/ugrad/engineer.html 9

http://www.princeton.edu/~seasweb/uinfo/bsegenrl.html 10

W.P. Keeton, *et al.*, *Prosser & Keeton on Torts* (5th ed. 1984) 23, 27

K.W. Li & A.P. Priddy, *Power Plant System Design* (1985) 9

W.J. Lux, *An Engineer in the Courtroom* (1995) 14

McGraw-Hill Dictionary of Scientific & Technical Terms, 5d. (1994) 6, 7, 8

J.D. Mustard, *Computers in Motor Vehicle Accident Reconstruction: A Review*, SAE Paper No. 871995 (1987) 25

R. Noon, *Introduction to Forensic Engineering* (1992) 9, 18

H. Petroski, *Invention by Design: How Engineers Get From Thought to Thing* (1996) 12, 28

H. Petroski, *Remaking the World: Adventures in Engineering* (1997) 6, 7, 9

H. Petroski, *To Engineer is Human: the Role of Failure in Successful Design* (1992) 6, 9, 11

K. Popper, *Conjectures and Refutations: The Growth of Scientific Knowledge* (5th ed. 1989) 6

B.T. Ray, *Environmental Engineering* (1995) 8

John D. Reid, *et al.*, eds., *Crashworthiness and Occupant Protection in Transportation Systems: Proceedings of the 1995 ASME International Mechanical Engineering Congress and Exposition* (1995). 10

Kevin L. Rens, ed., *Forensic Engineering: Proceedings of the First congress Sponsored by the Forensic Engineering Division of the American Society of Civil Engineers* (1997) 10

Restatement of the Law (Second) Torts (1965) 23

H.P. Rossmanith, ed., *Structural Failure, Product Liability and Technical Insurance, IV* (1993) 10

T. Russell and M. Denn, *Introduction to Chemical Engineering Analysis* (1972) 7

M Schwartz & N. Schwartz, *Engineering Evidence* (3rd ed. 1996) 9, 12, 14, 23, 24, 25

Society of Automotive Engineers, *41st Stapp Car Crash Conference Proceedings* (1997) 10

Society of Automotive Engineers, *SAE Handbook: On-Highway Vehicles and Off-Highway Machinery* (1997) 25

J.W. Strong, *et al.*, *McCormick on Evidence* (4th ed. 1992) 20

Technical Council on Forensic Engineering, *Guidelines For Failure Investigation* (1989) 24

Webster's Third International Dictionary (1971) ... 6, 7, 8

J.H. Wigmore, *Evidence in Trials at Common Law* (Chadbourn rev. 1981) 19

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INTEREST OF *AMICI CURIAE* [1]

Amici are scholars, teachers and practitioners of engineering:

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[1] Pursuant to Rule 37.6 of the Rules of this Court, *amici* state that no counsel for a party authored this brief in whole or in part, and no person or entity other than *amici* and their counsel made any monetary contribution to the preparation or submission of this brief. Pursuant to Rule 37.3, *amici* state that the parties have granted blanket consent to the filing of briefs by *amici* supporting either party. The letter granting this consent is being lodged separately with the Court.

John C. Allen retired in 1996 as Traffic Engineering Division Chief, Arlington County Department of Public Works, Arlington, Virginia.

Gregory B. Baecher is Professor and Chairman, Civil Engineering Department, University of Maryland.

Edward J. Bouwer is Professor of Environmental Engineering, Department of Geography and Environmental Engineering, The Johns Hopkins University.

Everett C. Carter is Professor of Civil Engineering, University of Maryland.

Stephen W. Director is Robert J. Vlasic Dean of Engineering and Professor of Electrical Engineering and Computer Science, University of Michigan.

Richard L. Meehan is Consulting Professor of Engineering, Stanford University.

Gene F. Parkin is Professor, Department of Civil and Environmental Engineering and Director, Center for Health Effects of Environmental Contamination, University of Iowa.

Bruce E. Rittman is John Evans Professor of Environmental Engineering, Northwestern University.

Yaron M. Sternberg is Professor of Civil Engineering at the University of Maryland.

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J. Christopher Wilt is Director, Boeing Nacelle Components Program, Commercial Aircraft Division, Northrop Grumman.

M. Gordon Wolman is Professor of Geography, Department of Geography and Environmental Engineering, The Johns Hopkins University.

The qualifications of *amici*, the positions they hold and have held, and the scholarly honors and distinctions they have earned are listed in greater detail in Appendix A to this brief.

Amici have no interest in the outcome of this case, and take no position on whether the failure of the tire in this case was caused by a defect in its design or manufacture. We appear solely as individuals, on our own behalf, to provide the Court with our views on the proper role of science and the scientific method in deciding whether to admit or exclude expert testimony on engineering issues.

SUMMARY OF ARGUMENT

Trial courts should play the same gatekeeping role for expert testimony on engineering issues that the Court prescribed in *Daubert* v. *Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579 (1993), for expert testimony on questions of pure science. *First*, engineering knowledge is "scientific" under Rule 702 of the Federal Rules of Evidence, because it is acquired and validated by the scientific method. *Second*, unvalidated engineering opinions have the same potential to mislead juries as do unvalidated opinions in the pure sciences. *Third*, trial courts should not abdicate their gatekeeping role where engineering testimony purports to be

based solely on the witness's "experience" and "training" or disclaims reliance on any "particular method or technique": this exception would swallow the *Daubert* rule. Moreover, the *Daubert* screening criteria are flexible enough to allow trial courts to accept scientific propositions that are undisputed or noncontroversial with less rigorous support than required for disputed propositions.

The four specific screening factors suggested by the Court in *Daubert*—falsifiability and testing of the theory, publication and peer review, the known or potential rate of error, and general acceptance in the scientific community—are also appropriate for screening engineering testimony. While not every factor will be relevant to every engineering issue, *Daubert* emphasizes that the inquiry under Rule 702 is flexible. Analysis of two important and recurring topics of engineering testimony—accident causation and product defect—illustrates the power and versatility of the *Daubert* factors.

ARGUMENT

I. BEFORE ADMITTING EXPERT TESTIMONY ON ENGINEERING ISSUES, TRIAL COURTS SHOULD MAKE AN INDEPENDENT ASSESSMENT OF ITS SCIENTIFIC VALIDITY AND RELEVANCE.

Rule 702 of the Federal Rules of Evidence provides:

> If *scientific, technical, or other specialized knowledge* will assist a trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise.

Fed. R. Evid. 702 (emphasis added). Five years ago, in *Daubert* v. *Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579 (1993), this Court held that trial courts, before admitting expert testimony proffered on "scientific" issues under Rule 702, must make a "preliminary assessment" that the "reasoning or methodology" underlying the testimony (1) "is scientifically valid" or reliable and (2) "can be applied to the facts at issue" well enough to assist the jury. *Id.* at 589-95; see also *General Elec. Co.* v. *Joiner*, 118 S. Ct. 512, 517 (1997) (district court decisions to admit or exclude expert scientific evidence may be overturned only for abuse of discretion).

The present case asks whether trial courts should play the same gatekeeping role for expert testimony on engineering issues. We believe that the answer is yes.

A. Engineering Knowledge Is "Scientific Knowledge" Under Rule 702.

Science is less a fixed body of knowledge than a process for testing theories. "[T]o qualify as 'scientific knowledge,' an inference or assertion must be derived by the scientific method." *Daubert*, 509 U.S. at 590. "The adjective 'scientific' implies a grounding in the methods and procedures of science." *Id.*

The scientific method is an iterative process of creating and testing hypotheses or theories that try to explain some aspect of the world. *Id.* A theory merits acceptance only if it survives repeated efforts to falsify or disprove it—by proof of its internal inconsistency, or its inconsistency with observed data or the results of controlled experiments.

Moreover, this testing process is incomplete unless the theory and supporting data are published in peer-reviewed journals or other forums in sufficient detail to allow other scientists to test the theory. No scientific theory can be proven true with absolute certainty, but a theory that survives varied and rigorous attempts at falsification gains general acceptance, and is regarded as scientifically reliable. *Id.* at 590-95; K. Popper, *Conjectures and Refutations: The Growth of Scientific Knowledge* 37 (5th ed. 1989).

Engineering is an applied science. The pure sciences—physics, chemistry, biology, geology and their subdisciplines—use the scientific method to explain the existing world. Engineering, in contrast, applies scientific knowledge and methods to create useful things that did not *exist* before. "The scientist seeks to understand what is; the engineer seeks to create what never was." H. Petroski, *Remaking the World: Adventures in Engineering* (1997) at ix (attributing statement to Theodore von Kármán); *see also* H. Petroski, *To Engineer Is Human: The Role of Failure in Successful Design* 49 (1992) ("[T]he discipline of taking the universe of structural elements as one's field of study is known as engineering science"); *Webster's Third International Dictionary* 752 (1971) (Engineering is a "science by which the properties of matter and the sources of energy in nature are made useful to man in structures, machines and products"); *McGraw-Hill Dictionary of Scientific & Technical Terms* 681 (5th ed. 1994) (same).

For example, bioengineers apply scientific knowledge to the biosynthesis or processing of animal or plant products.[2] Chemical engineers apply the "scientific principles underlying the transport of mass, energy, and momentum, and the physical and chemical change of matter" to design facilities and processes for making or using chemicals on a commercial scale.[3] Civil engineers apply knowledge of physics, chemistry and biology to design bridges, highways, harbors, water works, sewage treatment plants, airports, and private buildings.[4] Electrical engineers apply chemistry and physics to design electric power networks, communications and telecommunications systems, computers, and other devices that use electricity.[5] Environmental engineers apply knowledge of physics, chemistry and biology, *inter alia*,

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[2] *See McGraw-Hill Dictionary of Scientific & Technical Terms* 226; *Webster's Third International Dictionary* 218.

[3] T. Russell and M. Denn, *Introduction to Chemical Engineering Analysis* 5 (1972); *see also McGraw-Hill Dictionary of Scientific & Technical Terms* 355 (chemical engineering "serv[es] those industries that chemically convert basic raw materials into a variety of products, and deal[s] with the design and operation of plants and equipment to perform such work").

[4] H. Petroski, *Remaking the World*, *supra*, at 80-81; *see also McGraw-Hill Dictionary of Scientific & Technical Terms* 379 (civil engineering involves "[t]he planning, design, construction, and maintenance of fixed structures and ground facilities for industry, transportation, use and control of water, or occupancy").

[5] *See McGraw-Hill Dictionary of Scientific & Technical Terms* 649 (electrical engineering "deals with practical applications involving current flow through conductors, as in motors and generators").

to minimize pollution of air, water and soil.[6] Geological and geotechnical engineers apply scientific knowledge to the design of dams, mines, building and bridge foundations, and underground works such as tunnels.[7] Industrial engineers apply scientific knowledge to maximize the quality and quantity of the goods and services produced by industrial enterprises, and minimize their accident rate and other costs.[8] And mechanical engineers apply scientific knowledge to design automobiles, power plants, tools, and other machinery.[9]

All of these engineers play a complementary role when a product or process fails. Engineers use scientific knowledge to investigate (1) the cause(s) of the failure, and (2) the availability, practicality and cost of any alternative designs that could have prevented it. *See* J. Collins, *Failure of*

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[6] B. T. Ray, *Environmental Engineering* 2 (1995); *see also McGraw-Hill Dictionary of Scientific & Technical Terms* 686 (environmental engineering is "concerned with the reduction of pollution, contamination, and deterioration of the surroundings in which humans live").

[7] *See McGraw-Hill Dictionary of Scientific & Technical Terms* 681; *Webster's Third International Dictionary* 752.

[8] *Webster's Third International Dictionary* 1155; *see also McGraw-Hill Dictionary of Scientific & Technical Terms* 1009 (industrial engineering is "concerned with the design, improvement and installation of integrated systems of people, materials and equipment").

[9] *Webster's Third International Dictionary* 1401; *see also McGraw-Hill Dictionary of Scientific & Technical Terms* 1230 (mechanical engineering "deals with the generation, transmission, and utilization of heat and mechanical power and with the production of tools, machines, and their products").

Materials in Mechanical Design (2d ed. 1993); R. Noon, *Introduction to Forensic Engineering* (1992); H. Petroski, *To Engineer Is Human: The Role of Failure in Successful Design* (1992). These disciplines, often known as failure analysis or forensic engineering, are the ones most familiar to courts.[10]

Whether creating or investigating, an engineer relies on knowledge gained through the scientific method. *First*, engineering shares with the pure sciences the theories, data and other intellectual capital produced by physicists, chemists, biologists and other natural scientists. *See* H. Petroski, *Remaking the World*, *supra*, at 15 ("Engineers are clearly engaged in making discoveries or inventions with the 'fields' of physics and chemistry . . . ."); K.W. Li & A.P. Priddy, *Power Plant System Design* 21 (1985) ("The design of electric power generating systems starts with application of . . . the first and second laws of thermodynamics").[11] Indeed, the basic scientific courses learned by engineering students are often identical to the courses learned by their peers in the physics, chemistry and biology departments.[12]

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[10] *See* R. Noon, *supra*; M. Schwartz & N. Schwartz, *Engineering Evidence* (3d ed. 1996).

[11] *See also* M. Denn, *The Identity of Our Profession*, in 16 *Advances in Chemical Engineering: Perspectives in Chemical Engineering, Research and Education* 567 (C.K. Colton, ed., 1991) (major advances in chemical engineering "have been externally driven by scientific advances" in chemistry, physics, and molecular biology).

[12] *See* http://www.engin.brown.edu/Academics/Philosophy.html (undergraduate engineering curriculum at Brown University "stres[ses] basic scientific principles which underlie present and future engineering practice"); http://www.jhu.edu/~admis/catalog/ugrad/engineer.html (engi-

Second, engineers conduct a vast amount of experimental research in their own right, published in a welter of peer-reviewed engineering journals. (Appendix B to this brief provides a selective list.) Original scientific research by engineers also appears in studies and reports published by federal and state agencies, industry groups, and independent research bodies.[13]

Third, the making and empirical testing of scientific hypotheses are implicit in every engineering design project:

> [I]nstead of hypothesizing about the behavior of a given universe, whether of atoms, honeybees, or

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neering curriculum at The Johns Hopkins University "stresses the physical, mathematical, and computational sciences as a foundation for more advanced study"); http://www.princeton.edu/~seasweb/uinfo/-bsegenrl.html (engineering curriculum at Princeton University "emphasizes the fundamental principles of mathematics and the physical and engineering sciences").

[13] *E.g.*, *Crashworthiness of Transportation Systems: Structural Impact and Occupant Protection* (J. Ambrósio *et al.*, eds., 1996); *Structural Safety & Reliability: Proceedings of ICOSSAR '89, The 5th Annual Int'l. Conf. on Structural Safety and Reliability* (A. H-S. Ang, *et al.*, eds., 1989) (3 vol.); *Structures Under Shock and Impact II: Proceedings of the Second International Conference* (P.S. Bulson, ed., 1992); *Crashworthiness and Occupant Protection in Transportation Systems: Proceedings of the 1995 ASME International Mechanical Engineering Congress and Exposition* (John D. Reid, *et al.*, eds.); *Forensic Engineering: Proceedings of the First Congress Sponsored by the Forensic Engineering Division of the American Society of Civil Engineers* (Kevin L. Rens, ed., 1997); *Structural Failure, Product Liability and Technical Insurance, IV* (H.P. Rossmanith, ed., 1993); Society of Automotive Engineers, *41st Stapp Car Crash Conference Proceedings* (1997); 10 C.F.R. Part 473 (providing federal funding for "Automotive Propulsion Research and Development").

> planets, engineers hypothesize about assemblages of concrete and steel that they arrange into a world of their own making.

H. Petroski, *To Engineer Is Human*, *supra*, at 43. When an engineer designs a computer chip, hair dryer, automobile, bridge, or sewage treatment plant—or a component of it—he or she is hypothesizing that the design will achieve the required level of performance and cost, and withstand a foreseeable set of forces without failure, throughout the anticipated life of the object. *Id.* at 43-44. Premature failure, whether gradual or catastrophic, is the ultimate falsification of this hypothesis. *Id.* at 44-45, 83, 104-05. Engineers study the success and failure of existing designs, and this study affects the evolution of later designs. *Id.* at 210-12; *see also* note 13, *supra*.

Finally, the scientific method is also at the heart of failure analysis or forensic engineering. The scientific method furnishes an arsenal of techniques for determining why a product or process has failed. For example, engineers can test potential causes of tire failure by experimenting with tires made with missing or defective components, run with too heavy a load, insufficient air pressure, or thin or bald treads, or run over potholes or bumps. Tests of these kinds can generate failure curves for each potential cause, and reveal its characteristic markings in the tire carcass.[14]

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[14] *See Hewitt* v. *B.F. Goodrich Co.*, 732 F.2d 1554, 1558 (11th Cir. 1984) (noting expert's testing of allegedly defective tires); *Diviero* v. *Uniroyal Goodrich Tire Co.*, 919 F. Supp. 1353, 1356 (D. Ariz. 1996) (noting expert's "control group testing" and "failed tire analysis"), *aff'd*, 114 F.3d 851 (9th Cir. 1997); *Williams* v. *Michelin Tire Corp.*, 496 So. 2d 743, 745 (Ala. 1986)

Likewise, engineers can devise computer models to project a groundwater contaminant to its sources by accounting for its advection, dispersion, and reaction. The validity of these models can be tested empirically against the observed transport and fate of the same contaminant in controlled release studies. C.W. Fetter, *Contaminant Hydrogeology* (1993).

Engineers also use the scientific method to test the hypothesis that an alternative design could have prevented failure of a product or process without impairing its performance or destroying its cost effectiveness. An engineer can obtain performance data by testing a device in the laboratory or field. He or she can also look at the laboratory or field performance of similar devices and draw conclusions by comparison.[15]

(describing expert's analysis of failure patterns in tires); *see generally* 1 Schwartz & Schwartz, *Engineering Evidence* § 3.28 at 3-44 to -45 (describing processes of "destructive" and "non-destructive" testing).

[15] *See* A. Ertas & J. Jones, *The Engineering Design Process* 23 (2d ed. 1996) ("Development testing is an essential element in most detailed-design processes. It is used to determine design requirements, evaluate new concepts, obtain information on the performance of proposed components and subassemblies, [and] validate computational models as well as the design itself . . . ."); H. Petroski, *Invention by Design: How Engineers Get From Thought to Thing* 89-91 (1996) (discussing importance of "test[ing] a proposed design" against "failure criteria" to allow the "engineer to modify and remodify the design until it is ready to be realized").

B. The Policies Underlying *Daubert* Apply With Equal Force To Expert Testimony By Engineers.

The case for judicial assessment of the reliability and relevance of expert engineering testimony does not rest solely on its classification as "scientific" rather than "technical" under Rule 702. The threshold requirement of Rule 702 that expert testimony must "assist the trier of fact to understand the evidence or . . . determine a fact in issue" applies regardless of whether the "specialized knowledge" is "scientific" or "technical." Fed. R. Evid. 702.[16] Unvalidated engineering testimony, whether viewed as "scientific" or "technical," poses the same risk of jury confusion that concerned the Court in *Daubert*. Hence, a judicial gatekeeper role is equally warranted under Rule 702 in either event.[17]

Like the epidemiological testimony at issue in *Daubert*, unvalidated engineering testimony "can be both powerful and quite misleading because of the difficulty in evaluating it." Cf. *Daubert*, 509 U.S. at 595. The substance and methodology of engineering can be alien to lay persons, and its mathematical expression unintelligible. "As science and technology continue to develop, the gap between the lay-person's comprehension of this technology and the

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[16] Likewise, the overarching purpose of evidentiary rules is to ensure that "truth may be ascertained and proceedings justly determined." Fed. R. Evid. 102.

[17] In *Daubert*, the Court expressly left unresolved whether courts should play a similar gatekeeping role under Rule 702 for nonscientific "technical, or other specialized knowledge." 509 U.S. at 590 n. 8.

technology itself expands." Schwartz & Schwartz, *Engineering Evidence* § 1.1 at 1-2. Juries confronted with engineering disputes "c[an] easily miss subtle distinctions revealed on cross-examination and then drown in the untrue and the unproven." *Guillory* v. *Domtar Industries Inc.*, 95 F.3d 1320, 1331 (5th Cir. 1996) (excluding engineering testimony on cause of forklift accident as unvalidated under *Daubert*); see also *Smelser* v. *Norfolk Southern Ry. Co.*, 105 F.3d 299 (6th Cir. 1977) (engineering testimony that persuaded a jury to award $3.5 million for an allegedly defective seatbelt was incompetent and scientifically invalid). Instead of a joinder of issues refereed by the scientific method, the jury gets dueling résumés.[18]

Just as important, inadequate explanation and validation of engineering testimony can thwart other experts from helping the lay factfinder. A good engineering expert witness can break down even highly technical concepts into terms digestible by lay persons, and can highlight errors or unprove assumptions that lay jurors might otherwise overlook. W.J. Lux, *An Engineer in the Courtroom* 98-101 (1995). To perform this role effectively, however, the expert must understand fully the other side's testimony. What is true in academic research is equally true in the courtroom: unavailability of the data, assumptions and methodologies

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[18] *Cf. Watkins* v. *Telsmith, Inc.*, 121 F.3d 984, 991 (5th Cir. 1997) ("application of the *Daubert* factors is germane to evaluating whether the expert is a hired gun or a person whose opinion in the courtroom will withstand the same scrutiny that it would among his professional peers"); *Tyus* v. *Urban Search Management*, 102 F.3d 256, 263 (7th Cir. 1996) (under *Daubert*, trial court must evaluate an expert's methodology to ensure "that [the court] is dealing with an expert, not just a hired gun").

explicitly or implicitly underlying an engineering expert's conclusions deprives other engineers of the ability to test, analyze, replicate, or falsify the conclusions. Instead of a joinder of issues refereed by the scientific method, the jury gets dueling résumés and in-court performers.

C. Trial Courts Should Not Abdicate Their Gatekeeping Role For Engineering Testimony That Disclaims Any Scientific Basis.

Although most of the Courts of Appeals have agreed that engineering has a scientific basis, several—including the *Carmichael* court below—have created an exception to *Daubert* for engineering testimony that purports to rest solely on the "training" and "experience" of the witness, or disclaims reliance on any "particular method or technique" of science. See *Compton* v. *Subaru of America, Inc.*, 82 F.3d 1513, 1517-20 (10th Cir. 1996); *McKendall* v. *Crown Control Corp.*, 122 F.3d 803, 806-08 (9th Cir. 1997); *Carmichael* v. *Samyang Tire, Inc.*, 131 F.3d 1433, 1435-36 (11th Cir. 1997). The Court should reject such an exception.

All expert testimony—scientific or otherwise—offered under Rule 702 must be based on the expert's personal experience ("experience" or "skill") or the experience of others ("knowledge," "training" or "education"); otherwise the expert would be unqualified to testify. Fed. R. Evid. 702; *Daubert*, 509 U.S. 590 n. 8. The point of *Daubert* is that, when an expert offers scientific inferences in court, "experience" and "skill" unmediated by the scientific method are not enough. See *Joiner*, 118 S. Ct. at 519 ("[N]othing in either *Daubert* or the Federal Rules of Evidence requires a district court to admit opinion evidence which is connected to

existing data only by the *ipse dixit* of the expert"); see also *Daubert* v. *Merrell Dow Pharmaceuticals, Inc.*, 43 F.3d 1311, 1315-16 (9th Cir. 1995) (on remand) ("something doesn't become 'scientific knowledge' just because it's uttered by a scientist").

Engineers and other scientists are no more immune than other people from error and self-delusion. The "scientific literature is a vast collection of individual contributions, highly variable in quality." K. Foster & P. Huber, *Judging Science: Scientific Knowledge and the Federal Courts* 155-57 (1997). Most of the theories published by scientists are ultimately scrapped. *Id.* at 161. The cumulative process of empirical testing and retesting by scientists and their peers is a powerful engine of truth, however, and the resulting intellectual edifice is "very trustworthy indeed." *Id.* at 157; cf. *Daubert*, 509 U.S. at 597.

An exception to the *Daubert* rule for scientific inferences that do not even pretend to have scientific support would abdicate the courts' responsibility to ensure that testimony offered under Rule 702 is reliable and relevant enough to "assist the trier of fact." Fed. R. Evid. 702; *Daubert*, 509 U.S. at 589-90, 597. Entrusting the fate of litigants to scientifically untested engineering "experience" would be akin to entrusting the public safety to airplanes, bridges and skyscrapers built according to untested design principles.

Moreover, an exception for engineering testimony that disclaims any scientific foundation would admit most readily the testimony which is least reliable. The Eleventh Circuit illustrates this paradox. Six months after rendering its decision in *Carmichael*, the court applied *Daubert* to exclude

the testimony of a fire causation expert for lack of an adequate scientific foundation. *Michigan Millers Mut. Ins. Corp.* v. *Benfield*, 140 F.3d 915, 919-21 (11th Cir. 1998). The court distinguished *Carmichael* on the ground that the fire expert in *Benfield* had tried, albeit unsuccessfully, to show that his testimony "complied with the scientific method within his field of science." *Id.* at 920. Under *Carmichael* and *Benfield*, engineering testimony that tries to establish a scientific basis for its conclusions faces the rigors of *Daubert*; testimony that makes no such effort goes directly to the jury. "The moral of this approach would be, the less factual support for an expert's opinion, the better." *Watkins* v. *Telsmith, Inc.*, 121 F.3d 984, 991 (5th Cir. 1997).

Indeed, the logic of *Carmichael* and similar cases would have swallowed completely the salutary rule of *Daubert*. While the notion that consuming Bendectin, the drug at issue in *Daubert*, significantly increases the risk of birth defects has been overwhelmingly discredited by peer-reviewed epidemiological studies, the "small but determined" band of scientists who testified to the existence of such a link in lawsuit after lawsuit were well-trained and experienced.[19]

Allowing engineering testimony to escape *Daubert* scrutiny by disclaiming reliance on any "particular method or technique" would be equally unwarranted. *All* engineering testimony that draws conclusions from observed facts relies,

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[19] *Daubert*, 509 U.S. at 583 & n. 2; *Daubert* v. *Merrell Dow Pharmaceuticals, Inc.*, 43 F.3d 1311, 1318 & n.9 (9th Cir. 1995) (on remand); R.L. Brent, "Bendectin: Review of the medical literature of a comprehensively studied human nonteratogen and the most prevalent tortogen-litigen," 9 *Reproductive Toxicology* 337 (1995).

explicitly or implicitly, on scientific methods or inferences. And every reconstruction of an accident involves use of the scientific method to test hypotheses about its cause(s). R. Noon, *Introduction to Forensic Engineering* 41-43 (1992). That the hypotheses and their underlying assumptions may go unstated makes them no less critical.

The engineering testimony at issue in *Carmichael* is a good illustration. The Carmichaels' expert testified that the tire failure stemmed from a design or manufacturing defect, not abuse by a user. 131 F.3d at 1434. The Eleventh Circuit held that this claim does not rest on "any scientific theory of physics or chemistry." *Id.* In fact, the expert's conclusion rests on a chain of scientific assumptions: (1) the tire failed because its rubber, steel, and nylon components separated; (2) other than a design or manufacturing defect, the only possible cause of this separation was overdeflection of the sidewalls from underinflation or overloading;[20] and (3) although four tell-tale signs of overdeflection (uneven tread wear, sidewall deterioration or discoloration, abnormal bead grooving, and rim flange impressions) were present on the tire carcass, the overdeflection was not severe or sustained enough to cause tire failure. 923 F. Supp. 1514, 1519 (S.D. Ala. 1996). These assumptions rest in turn on a host of underlying assumptions about the physical and chemical traits and failure modes of rubber, steel, bonding compounds,

[20] The Carmichaels' expert, while conceding that the separation of the tire components "most likely began under a bald spot on the tire," 923 F. Supp. at 1519, apparently assumed that running a tire past the service life of the tread is not a form of abuse that could cause the tire components to separate.

and other tire components. Whatever the validity of these assumptions, they are by their nature clearly scientific. Cf. *Diviero* v. *Uniroyal Goodrich Tire Co.*, 919 F. Supp. 1353 (D. Ariz. 1996) (noting scientific complexity of tire failure analysis), *aff'd*, 114 F.3d 851 (9th Cir. 1997).

Compton, *McKendall*, *Carmichael* and similar decisions do reflect an important insight: some principles of science or engineering are so universally accepted that reconfirming them by scientific testing in individual lawsuits would be pointless and wasteful. If a drunk driver slams his car into the side of a house, and the homeowner hears a china cabinet crashing to the floor of the next room an instant later, it would be pedantic to require the homeowner to hire an engineer or physicist to verify the hypotheses that the momentum of the car was transferred through the structure of the house to the china cabinet, and that the transferred momentum caused the china cabinet to lean over too far to resist the gravitational pull of the earth. These hypotheses, while scientific, can hardly be disputed.

The logical way for trial courts to deal with non-controversial scientific hypotheses or inferences is not by abandoning the courts' gatekeeping role, but by applying *Daubert* flexibly to account for the widespread or universal acceptance of some scientific propositions. Indeed, some scientific propositions are established firmly enough to warrant their admission by judicial notice.[21]

[21] *Daubert*, 509 U.S. at 592 n. 11 (citing Fed. R. Evid. 201); 9 J.H. Wigmore, *Evidence in Trials at Common Law* § 2580 at 796-97 (Chadbourn rev. 1981) ("Courts are found noticing . . . a varied array of unquestionable facts ranging throughout the data of . . . natural science");

The beekeeper analogy invoked in *Carmichael* and other recent cases neatly illustrates this distinction. See *Carmichael*, 131 F.3d at 1435-36 (quoting *Berry* v. *City of Detroit*, 25 F.3d 1342, 1349-50 (6th Cir. 1994)). The Sixth and Eleventh Circuits are mistaken in characterizing a beekeeper's testimony that "bumblebees always take off into the wind" as nonscientific. Unless the testifying beekeeper has observed all species of bees, at all stages of life, in all seasons, and in all ecological niches throughout the world, the beekeeper is implicitly hypothesizing that some underlying scientific cause induces all bees—observed and unobserved—to take off upwind. This assumption, whether stated or not, is a scientific hypothesis.[22] We allow the beekeeper to draw this inference not because it is nonscientific, but because it is (by assumption) noncontroversial. Should an entomologist or rival beekeeper materialize in the courtroom to testify that some bees take off downwind, a responsible trial judge would require properly validated experimental or empirical data to resolve the issue.

Likewise, the Eleventh Circuit errs in describing as "nonscientific" the testimony of an experienced auto mechanic that the burns or marks on a spark plug reveal the cause of

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2 J.W. Strong, *et al.*, *McCormick on Evidence* § 330 at 397 (4th ed. 1992) ("In the increasingly important practice of judicial notice of scientific and technological facts . . . courts may fail to employ the doctrine of judicial notice . . . to the full measure of its usefulness").

[22] The hypothesis presumably is that taking off upwind produces greater airspeed and aerodynamic lift than would taking off downwind, and that bees which possess the trait of taking off upwind are more likely to escape predators and produce offspring.

its failure. *Carmichael*, 131 F.3d at 1436 n. 6. The mechanic's testimony rests on the scientific hypothesis that each cause of sparkplug failure consistently generates a characteristic set of marks. If this hypothesis is undisputed, impressionistic or anecdotal testimony from an auto mechanic may be ample to support it. Indeed, a scientific claim not seriously in dispute is unlikely to lead to a *Daubert* motion in the first place. See Fed. R. Civ. P. 11.

If a scientific claim is genuinely in dispute, however, a trial court should insist on scientifically validated empirical data.[23] To dispense with scientific validation of expert testimony on disputed scientific claims because less validation may be adequate for undisputed scientific claims is to assume away the problem.

II. THE SPECIFIC SCREENING FACTORS SUGGESTED IN *DAUBERT* ARE APPROPRIATE FOR ENGINEERING TESTIMONY.

In *Daubert*, the Court offered a suggested checklist of four factors for trial courts to consider in deciding whether scientific testimony is sufficiently reliable to submit to a jury:

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[23] This is not to suggest that an engineering degree is a prerequisite for valid engineering testimony: the scientific method is not credentialism. Experienced auto mechanics may have a great deal of native engineering ability, and research by self-trained inventors like Benjamin Franklin, Thomas Edison and the Wright brothers has done much to advance scientific knowledge. Whether Ph.D. or autodidact, however, a witness cannot draw scientifically reliable conclusions without rigorous application of the scientific method.

(1) Is the expert's theory or technique "falsifiable"—can it be tested against empirical data? Has it been tested?

(2) Has the theory or technique been published in peer-reviewed professional journals?

(3) What is the known or potential rate of error of the scientific technique?

(4) Has the theory or technique received general acceptance within the scientific community?

See 509 U.S. at 592-595 (describing four factors). In addition, the trial court must determine that the engineering model properly fits the actual circumstances of the accident or failure. *Id.* at 591.

We believe that these factors are also useful for screening engineering testimony. To be sure, not all *Daubert* factors are relevant to every engineering issue, nor were they meant to be. 509 U.S. at 594 (emphasizing that inquiry under "Rule 702 is . . . a flexible one"). Taken as a whole, however, the *Daubert* guideposts are a useful analytic framework for exercising a trial court's gatekeeper role under Rule 702. While an exhaustive survey of the universe of engineering testimony is beyond the scope of this brief, two recurring issues—the cause of product failure and the efficacy of alternative designs—provide good illustrations of how the *Daubert* factors work in practice.

A. The *Daubert* Factors Are Appropriate For Assessing Expert Engineering Testimony On Issues Of Causation.

One of the most common tasks of expert engineering witnesses is identifying the cause of the plaintiff's injury. Regardless of the underlying theory of liability, causation is a basic issue in nearly every products liability case.[24] Expert testimony on this issue often is "essential."[25] When a car crashes, for example, a mechanical engineer's reconstruction of the sequence of events may be critical to deciding how the accident occurred and whether the plaintiff's injuries resulted from a defect in the vehicle.

Accident reconstruction is rife with snares for the uninitiated, for it requires understanding of "the physical and dynamic elements of the vehicles, characteristics of the roadway, environment, human factors of the drivers, and the laws of physics." See 2 Schwartz & Schwartz, *Engineering*

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[24] *See* W.P. Keeton, *Prosser & Keeton on Torts* § 41 at 263 (5th ed. 1984) ("An essential element of the plaintiff's cause of action for . . . any tort, is that there be some reasonable connection between the act or omission of the defendant and the damage which the plaintiff has suffered"); *Restatement of the Law (Second) Torts* § 281 (1965) (negligence: "legal cause" of injury); *id.* § 402A (strict liability: injuries "caused" by product); 1 Frumer & Friedman, *Products Liability* § 3.01 at 3-2 & n.1 (1998) (collecting cases for proposition that "'Causation is a fundamental requisite for establishing any product-liability action'" (quoting *Coffman* v. *Keene Corp.*, 628 A.2d 710, 716 (N.J. 1993))).

[25] *See* 3 Frumer & Friedman, *Products Liability* § 18.06[4][b] at 18-144.5; *cf.* Schwartz & Schwartz, *Engineering Evidence* § 1.1 at 1-3 ("Engineering evidence is the backbone of litigation involving design, construction, and manufacturing").

Evidence § 8:44 at 8-173. The *Daubert* factors are an effective tool for protecting juries from "powerful" but "quite misleading" expert testimony on causation along with other issues. Cf. *Daubert*, 509 U.S. at 595.

First, an engineer's accident reconstruction methodology should be empirically tested by comparing its predictions with known data collected under controlled circumstances that are similar to the accident scenario at issue.[26] If an expert's reconstruction methodology has been tested and predicts accurately a vehicle's change in velocity when subjected to known forces in an accident sequence, the expert's application of that methodology likely will be helpful to the jury's assessment of the likely changes in velocity of a vehicle involved in a similar accident. Conversely, where a reconstruction methodology is un tested or has generated inaccurate results when measured against known data, its reliability in predicting the cause of a plaintiff's injuries is suspect.[27]

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[26] *See, e.g.*, J.E. Bernard & C.L. Clover, *Validation of Computer Simulations of Vehicle Dynamics*, SAE Paper No. 940231, Society of Automotive Engineers, at 160 (1994) ("*Validation* is the process of gaining confidence that the calculations yield useful insights into the behavior of the simulated vehicle in maneuvers of interest").

[27] *See* Technical Council on Forensic Engineering (American Society of Civil Engineers), *Guidelines For Failure Investigation* 38, 79-84, 107-18 (1989) (checklists of appropriate tests in investigation of geotechnical and structural failures); *cf.* Schwartz & Schwartz, *Engineering Evidence* § 8:41 at 8-159 ("[B]y comparing [the] amount of crush resulting in controlled impact to the amount of crush resulting in the investigated collision, approximate [vehicle] speeds may be estimated").

Second, peer review and publication of accident reconstruction techniques shed further light on the reliability of an expert's methodology.[28] As explained in *Daubert*, peer review and publication of an expert's methodology increases the odds of detecting any serious error in it. See *Daubert*, 509 U.S. at 593. Peer review plays, if anything, a greater role in engineering than in the pure sciences. Engineering peer review, institutionalized under the aegis of government agencies, professional societies, and trade associations, supplies many of the design and performance standards used by engineers in their daily work.[29] An accident construction technique that has never been published or subject to peer review lacks a relevant and independent index of reliability. *Id.* at 594; *Smelser* v. *Norfolk Southern Ry. Co.*, 105 F.3d 299, 303 (6th Cir. 1997) (quoting *Daubert*, 43 F.3d at 1317).

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[28] *See, e.g.*, T.D. Day & R. L. Hargens, *Application and Misapplication of Computer Programs for Accident Reconstruction*, SAE Paper No. 890738, Society of Automotive Engineers (Feb. 27 - Mar. 3, 1989) (analyzing use and misuse of computer simulation programs); J.D. Mustard, *Computers in Motor Vehicle Accident Reconstruction: A Review*, SAE Paper 871995, Society of Automotive Engineers (1987).

[29] *See, e.g.*, American Society for Testing and Materials, *Annual Book of ASTM Standards* § 00.01 at iii (1996) ("'standard' serves in ASTM as an adjective in the title of documents, such as test methods or specifications, to connote specified consensus and approval"); 3 Society of Automotive Engineers, *Standards Development Program, SAE Handbook: On-Highway Vehicles and Off-Highway Machinery* (1997) ("All SAE Standards are submitted to the American National Standards Institute for recognition as American National Standards"); *see also* Schwartz & Schwartz, *Engineering Evidence*, App. B (listing "governmental agencies, professional and trade societies, and materials and manufacturing associations" that publish engineering standards).

Third, in accident reconstruction, the known or potential rate of error is often important in evaluating the expert's methodology, particularly when the methodology relies on computer models, statistical regression analyses, or equipment that must be calibrated. *Id.* at 304.

Fourth, general acceptance (or lack thereof) of an expert's techniques and assumptions of a forensic engineering model also bears on its admissibility. As in *Daubert*, "[w]idespread acceptance can be an important factor in ruling particular evidence admissible, and a known technique which has been able to attract only minimal support within the community may properly be viewed with skepticism." 509 U.S. at 594 (internal citations and quotation marks omitted). At the other extreme, general acceptance of an engineering theory (e.g., the ~~t~~theory of gravitation) may be so universal and unchallenged that the theory can be admitted by judicial notice. See pp. 19-21, *supra*.[30]

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[30] Engineering evidence on causation should also be screened for compliance with the "fitness" prong of *Daubert*, which requires that scientific knowledge be relevant to (or "fit") the particular facts of a case. 509 U.S. at 591. For example, in *Habecker* v. *Clark Equipment Co.*, 36 F.3d 278 (3d Cir. 1994), the Court of Appeals upheld exclusion of an accident simulation which failed to "replicat[e]" the various accident components and thus did "not 'fit' the facts of th[e] case," *id.* at 290. Similarly, in *Pomella* v. *Regency Coach Lines, Ltd.*, 899 F. Supp. 335 (D. Mich. 1995), the court invoked the fitness prong of *Daubert* to disregard accident reconstruction testimony that attributed a bus-automobile collision to excessive speed by the bus driver: the court found that the record lacked credible evidence establishing the friction coefficient of the road surface, a key input to the accident reconstruction model. *Id.* at 342-43. And, in *Guillory* v. *Domtar Indus., Inc.*, 95 F.3d 1320 (5th Cir. 1996), the court of appeals affirmed the exclusion of an expert's demonstration video involving a model that

B. The *Daubert* Factors Are Appropriate For Assessing Expert Engineering Testimony On Issues Relating To Product Defect.

Engineering testimony also commonly focuses on whether a product is defective. Relevant to that inquiry is whether a safer alternative design is available, practicable and cost effective.[31] Here too, the *Daubert* framework provides a useful analytical tool for assessing the reliability and relevance of such testimony. The recent decision in *Cummins* v. *Lyle Industries*, 93 F.3d 362 (7th Cir. 1996), is instructive.[32]

The plaintiff in *Cummins* lost three fingers in a trim press while trying to empty its scrap chute. *Id.* at 364. Suing the manufacturer, she offered testimony by an agri- ural engineer that different control circuits and warning

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"differed in several respects from the forklift and the accident scene," *id.* at 1330, because the jury could "get lost in the labyrinth of concepts," *id.* at 1331.

[31] 2 Frumer & Friedman, *Products Liability* § 11.04[1] at 11-110 & n.1 ("Evidence of the existence of a safer alternative design that is both technologically and economically feasible and is also available to the manufacturer is ubiquitous in design defect cases") (collecting cases); Prosser, *Prosser & Keeton on Torts* § 99 at 701 ("The courts have almost universally held that the feasibility of designing a safer product must be determined as of the time the product was designed").

[32] *Accord Watkins* v. *Telsmith, Inc.*, 121 F.3d 984, 992-93 (5th Cir. 1997) (applying *Daubert* to affirm the exclusion of an engineer's proposed testimony regarding feasible alternative designs of a conveyor belt); *Pestel* v. *Vermeer Mfg. Co.*, 64 F.3d 382, 384 (8th Cir. 1995) (excluding evidence of proposed alternative engineering design based on *Daubert* factors).

information would have prevented the accident. *Id.* at 365-66. The expert acknowledged that testing was a necessary part of the design process, but admitted that he had done no testing of the cost and efficacy of his alternative designs. *Id.* at 368-69. The trial court, invoking *Daubert*, excluded his testimony on the alternative designs. *Id.* The Court of Appeals affirmed. Holding that *Daubert* covers testimony that "involves the application of science to a concrete and practical problem," *id.* at 367 n. 2, the court upheld the trial court's finding that the expert's "proffered opinions could not fairly be characterized as scientific knowledge." *Id.* at 369. In doing so, the Seventh Circuit demonstrated that the *Daubert* criteria could be adapted to a wide range of expert testimony in general, and were appropriate to an analysis of alternative design testimony in particular.

First, the court properly assigned great weight to the expert's failure to conduct any testing to "substantiate his opinion that alternative test designs feasibly could have been incorporated into [defendant's] trim press." *Id.* at 370.[33] Although building and testing an alternative design is not necessarily the only acceptable way to validate it,[34] the

[33] *Accord Watkins* v. *Telsmith*, Inc., 121 F.3d 984, 990-91 (5th Cir. 1997); *Duffee* v. *Thornton*, 879 F. Supp. 1078, 1087 (D. Kan. 1995) (illustrative checklist of factors to consider in evaluating viability of alternative product design).

[34] Reasoning by analogy from alternative designs that have worked in practice for similar purposes, or from well-tested underlying principles of physics or chemistry, may suffice. *Cummins*, 93 F.3d at 369; *see also* H. Petroski, *Invention by Design* 90 ("By understanding how and why a proposed design can fail, and by being able to calculate the quantities

expert's validation must satisfy accepted standards of good practice in the relevant field of engineering.[35] Just as it is improper to rely on epidemiological studies of dosages and other conditions "far-removed" from the plaintiff's circumstances, *General Elec. Co.* v. *Joiner*, 118 S. Ct. at 518, so it is improper to rely on tests of alternative designs or components that are far removed from the alternative proposed by the expert.

Second, the court noted that the plaintiff's expert had failed to publish any "writing or study concerning the incorporation of the alternative designs into a trim press." *Cummins*, 93 F.3d at 370. *Third*, the Seventh Circuit noted that the third *Daubert* factor, the rate of error, was irrelevant to his proposed testimony. *Id.* *Finally*, the court concluded that the expert's failure to test his proposed alternative designs was not "consistent with the generally accepted method for gathering and evaluating data in alternative design cases." *Id.*

needed to assess whether failure conditions prevail, the engineer is able to test a design on the drawingboard or on the computer screen before any steel is erected, any valve is opened, or any switch is thrown. . . ."); *but see id.* ("Some problems of engineering design do not lend themselves so much to analytical calculations as to trial-and-error or to build-and-measure techniques"); J.A. Collins, *Failure of Materials in Mechanical Design: Analysis, Prediction, Prevention* 305-07 (2d ed. 1993) (discussing alternatives to full-scale fatigue testing).

[35] *Watkins* v. *Telsmith*, 121 F.3d at 990 (citing *Cummins*, 93 F.3d at 369); *see also* A. Ertas & J. Jones, *The Engineering Design Process* 3 ("[T]he design process begins with an identified need and concludes with satisfactory qualification and acceptance testing of the prototype").

* * *

We believe that the *Daubert* criteria, if applied flexibly and with common sense, are well suited to evaluating the reliability and relevance of expert engineering testimony in general. Accordingly, in fulfilling its gatekeeper function, the trial court should begin its analysis of the admissibility of engineering testimony by analyzing the *Daubert* factors.

CONCLUSION

The judgment of the Court of Appeals should be reversed.

Respectfully submitted,

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August 25, 1998

APPENDICES

APPENDIX A

BACKGROUND AND QUALIFICATIONS OF *AMICI CURIAE*

JOHN ALLEN

Professional Employment

Traffic Engineering Consultant, Newport News, Virginia (1996-present)

Chief, Traffic Engineering Division, Department of Public Works, Arlington County, Virginia (1992-96)

Traffic Operations Engineer, Traffic Engineering Division, Department of Public Works, Arlington County, Virginia (1981-92)

Transportation Specialist, Office of Traffic Operations, Federal Highway Administration (1980-81)

Senior Traffic Engineering Consultant, JHK & Associates, Alexandria, Virginia (1971-80)

Transportation Consultant, Peat, Marwick, Mitchell & Co-Partners (1970-71)

Traffic Engineer, District of Columbia Department of Highways and Traffic (1960-70)

Staff Consultant, Murray & Dischinger, Engineers (1959-60)

Professional Affiliations

Institute of Transportation Engineers ("ITE")

Past Chairman, District 2

Past President, Washington, DC Section

Past Chairperson, Department 3, ITE Technical Council

Recipient, 1991 Past Presidents Award, Washington, DC Section ITE

American Public Works Association, Member

Registered Professional Engineer, Traffic Engineering, California

Education

Certificate, The Traffic Institute, Northwestern University (1968)

B.S., Engineering, Hampton University (1956)

GREGORY B. BAECHER

Professional Appointments

Professor of Civil Engineering and Chairman, Department of Civil Engineering, University of Maryland (1995-present)

President and CEO, ConSolve Incorporated (1988-95).

Professor and Head, Constructed Facilities Division, Department of Civil and Environmental Engineering, Massachusetts Institute of Technology (1975-88).

Visiting Professor, Technical University Munich (1980-81)

Rockefeller Foundation Post Doctoral Fellow, International Institute for Applied Systems Analysis, Vienna (1974-75)

Captain, U.S. Army Corps of Engineers (1972-73)

Awards

ASCE State of the Art Award, 1991.

ASCE Thomas A. Middlebrooks Award, 1995.

Papers in Press

Levy, B. and G.B. Baecher, "NileSim: A Windows-based Hydrologic Simulator of the Nile River System," *Journal of Water Resource Systems and Management, ASCE*

Baecher, G.B., "Judgmental Probability in Geotechnical Risk Assessment," prepared for the Office of the Chief, USACE.

Johnson, R.L., and G.B. Baecher, "Adaptive Site Characterization: Theory," *Journal of Geotechnical Engineering, ASCE.*

Johnson, R.L., and G.B. Baecher, "Adaptive Site Characterization: Applications," *Journal of Geotechnical Engineering, ASCE.*

Baecher, G.B., "Primer on Geotechnical Reliability"

Recent Publications

Baecher, G.B., J. Shapiro and J.A. Zarge, "SiteView-practical environmental visualization, Transportation Research Board Annual Meeting, Washington, DC (1995)

Johnson, R.L. and G.B. Baecher, "Sequential statistical visualization for site characterization," Transportation Research Board Annual Meeting, Washington, DC (1995)

Ladd, C.C., Christian, J.T., and G.B. BAECHER, "Reliability applied to slope stability analysis," Journal of the Geotechnical Engineering Division, ASCE, GT120(12): 2180-2207 (1994)

Baecher, G.B., "Environmental Data Management Short Course,"Superfund '94, Hazardous Materials Control Research Institute, Washington, DC, 1994.

DeGroot, D.J. and G.B. Baecher, "Estimating autocovariance of the in situ soil properties," *Journal of the Geotechnical Engineering Division, ASCE* (1993)

Baecher, G.B. and J.H. Hetrick, "Computer-aided Observational Approaches to Site Assessment," Air and Waste

Management Association, June 22-26, Kansas City, 1992.

Einstein, H.H. and G.B. Baecher, "Risks associated with rock engineering," in, Hunter, R., *et al., Calculating Probabilities of Geological Events* (1992)

Ladd, C.C., Christian, J.T., and G.B. Baecher, "Reliability and probability in stability analysis, 2 *Proc. Stability and Performance of Slopes and Embankments II, ASCE* 1071-1111 (1992)

Baecher, G.B. and L.A. McGrath, "The Virtual Site as a Tool for Remediation Using the Observational Method," Superfund '91, Hazardous Materials Control and Research Institute, Washington, 1991.

Baecher, G.B. and D.A. Sangrey, "Geotechnical engineering workbench," *American Society of Civil Engineers, Geotechnical Congress '91, Boulder* 1044-1056 (1991)

Baecher, G.B., L.A. McGrath, and L. Boulais, "CAE for geo/environmental engineers," 9(4) *Geotechnical News* 57-59 (1991)

Wu, T.H., W. Tang, G.B. Baecher, and D.A. Sangrey, "Reliability analysis of offshore structures: State of the art," *Journal of the Geotechnical Engineering Division, ASCE*, 116-1990.

Patents

Patent No 5,150,310 for Method and Apparatus for Position Detection CNM-001, Sept. 22, 1992

Education

Ph.D. in Civil Engineering, Massachusetts Institute of Technology (1972). Dissertation title, *Site Exploration: A probablistic approach.*

B.S. in Civil Engineering, University of California (1968).

EDWARD J. BOUWER

Appointments

Professor of Environmental Engineering, Department of Geography and Environmental Engineering, The Johns Hopkins University (1992-present)

Visiting Professor, Department of Microbiology, Agricultural University, Wageningen, The Netherlands (1992)

Associate Professor of Environmental Engineering, The Johns Hopkins University (1988-92)

Assistant Professor of Environmental Engineering, The Johns Hopkins University (1985-88)

Assistant Professor of Civil Engineering, University of Houston (1983-84)

Research Interests

Factors that influence biotransformation of organic contaminants, bioremediation for control of organic contaminants at waste sites, biofilm kinetics, interaction between biotic and abiotic processes, groundwater contamination, biological processes design in wastewater, industrial and drinking water treatment, and transport and fate of microorganisms in porous media.

Awards and Honors

AEEP Outstanding Thesis Award (jointly with Ph.D. student Robert Martin) (1991)

AEEP Outstanding Thesis Award (jointly with Ph.D. student Gordon Cobb) (1990)

Paper Award, AWWA Chesapeake Section (awarded jointly to A. Leeson) (1990)

Paper Award, AWWA Chesapeake Section (awarded jointly to G. Cobb and D. Lew) (1989)

First Prize, WPCF Paper Contest (awarded jointly to Ph.D. student Dennis Lew) (1988)

National Science Foundation Presidential Young Investigator Award (1985-90)

Outstanding Teaching Award, College of Engineering, University of Houston (1984)

AEEP Award, Best Doctoral Thesis Relevant to Environmental Engineering Practice (1982-83)

National Science Foundation Graduate Fellowship (1978-82)

Selected Publications

Durant, N.D., L.P. Wilson, and E.J. Bouwer, "Microcosm Studies of Subsurface PAH-Degrading Bacteria from a Former Manufactured Gas Plan," *J. Cont. Hydrol.*, 17:3, 213-237 (1995)

Rijnaarts, H.H.M, W. Norde, E.J. Bouwer, J. Lyklema, and A.J.B. Zehnder, "Bacterial Deposition in Porous Media: Effects of Cell Coating, Substratum Hydrophobicity, and Electrolyte Concentration," *Environmental Science and Technology* 30:10, 2877-83 (1996)

Wilson, L.P. and E.J. Bouwer, "Biodegradation of Aromatic Compounds Under Mixed Oxygen/Denitrifying Conditions," *J. Industrial Microbiology* 18, 116-130 (1997)

Hozalski, R.M. and E.J. Bouwer, "Deposition and Retention of Bacteria in Backwashed Filters," *J. Amer. Water Works Ass'n*, 90:1, 71-85 (1998)

Zhang, W., E.J. Bouwer, and W.P. Ball, "Bioavailability of Hydrophobic Organic Contaminants–Effects and Implications of Sorption-Related Mass Transfer on Bioremediation," *Ground Water Monitoring and Remediation*, 18:1, 126-38 (1998)

EVERETT C. CARTER

Academic Experience

Professor, Civil Engineering, University of Maryland (1972-present)

Director, Transportation Studies Center, University of Maryland (1975-85, 1987-present)

Chairman, Civil Engineering Department, University of Maryland (1973-77)

Associate Professor Civil Engineering, University of Maryland (1970-72)

Associate Professor, West Virginia University (1969-70)

Assistant Professor, West Virginia University (1963-69)

Teaching Assistant, Northeastern University (1961-62)

Scientific and Professional Societies

American Society of Civil Engineers

Transportation Research Board

Institute of Transportation Engineers

American Public Works Association

Sigma Xi

American Road and Transportation Builders Association

American Society for Engineering Education

Publications

Carter, E.C., (with Chang, G.L. and C.H. Chen) "Intervention Analysis for the Impacts of the 65 mph Speed Limit on Rural Interstate Highway Fatalities," 24 *Journal of Safety Research* 33-53 (1993)

"Will IVHS Transform System Effectiveness", *Proceedings, 3rd Annual Meeting/IVHS America* 210-223 (April 1993)

Editor, *Proceedings, IVHS America Workshop on IVHS Evaluation of Impacts*, December 1-3, 1992.

Carter, E.C., (with Horan, Stephens and Tadej) "Twelve Keys to Improved IVHS Evaluations," *Proceedings, ASCE Conference on Applications of Advanced Technology* 1993.

Education

Ph.D., Transportation, Northwestern University, 1969.

M.E., Transportation, University of California, Berkeley, 1959.

B.S.C.E., Virginia Polytechnic Institute, 1958

STEPHEN W. DIRECTOR

Appointments

Robert J. Vlasic Dean of Engineering and Professor of Electrical Engineering and Computer Science, University of Michigan (1996-present)

U.A. and Helen Whitaker University Professor of Electrical and Computer Engineering, Carnegie Mellon University (1977-96)

Dean, College of Engineering, Carnegie Mellon University (1991-96)

Head, Department of Electrical and Computer Engineering, Carnegie Mellon University (1982-91)

Founder and Director, SRC-CMU Research Center for Computer-Aided Design (1982-89)

Visiting Scientist, Mathematical Sciences Department, T.J. Watson Research Center, IBM (1974-75)

Department of Electrical Engineering, University of Florida, Gainesville (1968-77)

Current Professional Activities

Chair, National Academy of Engineering Academic Advisory Board

Chair, NAE Electronics Engineering Peer Committee for the 36th Election

Member, Board of Directors, Accreditation Board for Engineering and Technology (ABET)

Fellow of the Institute of Electrical and Electronics Engineers (IEEE) (elected 1978).

Past Professional Activities

President, IEEE Circuits and Systems Society (CAS)

Chairman, CAS Technical Committee on Computer-Aided Network Design (CANDE)

Associate editor, *IEEE Transactions on Circuits and Systems*

Selected Awards

IEEE Education Medal (1998)

First recipient of the Aristotle Award, Semiconductor Research Corporation (1996)

Outstanding Alumnus Award in Electrical Engineering, University of California, Berkeley (1996)

Outstanding Achievement Award, IEEE Education Society (1995)

Society Award (Van Valkenburg Award), IEEE Circuits and Systems Society (1992)

Best Paper Award, ACM/IEEE Design Automation Conference (1992)

National Academy of Engineering (elected in 1989)

Best Paper Award, IEEE Circuits and Systems Society (1985)

IEEE Centennial Medal (1984)

Distinguished Alumnus, State University of New York at Stony Brook (1984)

W.R.G. Baker Prize Paper Award, IEEE (1979).

Frederick Emmons Terman Award, American Society of Engineering Education (1976)

Best Paper Award from the IEEE Circuits and Systems Society (1970)

Publications

Author or co-author of over 150 papers and six texts

Education

B.S., State University of New York at Stony Brook (1965)

M.S. in electrical engineering, University of California, Berkeley (1967)

Ph.D. in electrical engineering, University of California, Berkeley (1968)

RICHARD L. MEEHAN

Academic Appointments

Consulting Professor, Stanford University (1974-present)

Adjunct Professor, San Jose State University (1989)

Other Professional Employment

Consulting Engineer, Richard L. Meehan Associates, Palo Alto, CA (1985-present)

President, Earth Sciences Associates, Palo Alto (1969-85). Management of and quality assurance for geotechnical and water resource engineering activities of 30-person firm. Safety evaluation, consultation, land, regulatory, and environmental review of water, power, and industrial facilities.

Project Engineer, W.A. Wahler and Associates, Palo Alto (1967-69). Site investigations and design for water reservoir, environmental and water supply projects, Northern and Southern California, South America.

Project Engineer, Thailand Royal Irrigation Dept., Lam Pra Plerng irrigation project, Thailand (1963-65).

Officer, U.S. Army Corps of Engineers; Instructor, U.S. Army Engineer School, Fort Belvoir (1961-63).

Professional Registration & Membership

Civil Engineer: California, Washington, Massachusetts

Geotechnical Engineer: California

American Society of Civil Engineers

National Groundwater Association

Association of Groundwater Scientists and Engineers

American Association for the Advancement of Science

Selected Publications

"California Housing Damage Related to Expansive Soils," 8:4 *J. for Performance of Constructed Facilities, ASCE* (May 1994)

"Key Technical Factors Relevant in Cleanup Negotiations," presented at the PNWIS Air & Waste Management Association Conference, Victoria, B.C. November 1993.

"A Natural History of Underground Fuel Tank Leakage," *Environmental Claims Journal*, vol 5, no 3; Spring 1993.

"Cause of the 1985 Ross Store Explosion and Other Gas Ventings, Fairfax District, Los Angeles," in *Engineering Geology Practice in Southern California*, Special Publication No. 4, Association of Engineering Geologists, 1992.

"The Battered Exclusion: Who Pays How Much for California Landslides", in *For The Defense*, DRI, 1987.

The Atom and the Fault: Earthquakes, Experts, and Nuclear Power, MIT Press, 1984.

Technical articles on geotechnical engineering and groundwater in the following journals: *Journal Geotechnical Engineering Division, ASCE; Civil Engineering; Consulting Engineering; Civil Engineering and Public Works Review; Science.*

Education

D.I.C. Imperial College of Science and Technology (1966)

M.Sc. (Soil Mechanics) University of London, England (1966)

B.S. (Civil Engineering) Massachusetts Institute of Technology (1961)

GENE F. PARKIN, P.E.

Professional Appointments

Chairman, Dept. of Civil and Environmental Engineering, The University of Iowa (1990-95)

Director, Center for Health Effects of Environmental Contamination, The University of Iowa (1988-present)

Professor of Civil and Environmental Engineering, The University of Iowa (1988-present)

Associate Professor of Civil and Environmental Engineering, The University of Iowa (1986-88)

Associate Professor of Civil Engineering, Drexel University (1981-86)

Assistant Professor of Civil Engineering, Drexel University (1978-81)

Acting Assistant Professor of Civil Engineering, Stanford University (1977)

Professional Societies and Registration

Member, Water Environment Federation

Member, Iowa Water Pollution Control Association

Member, American Society of Civil Engineers

Member, Iowa Groundwater Association

Member, American Water Works Association

Member, Association of Environmental Engineering Professors

Member, American Society for Microbiology

Member, International Association on Water Quality

Registered Professional Engineer, Iowa, No. 14226

Selected Professional Activities

Member, Technical Advisory Committee, State of Iowa, Brownfields Program (1997-98)

Vice Chair, National Research Council Committee on Environmental Remediation at Naval Facilities (1997-98)

Secretary, Association of Environmental Engineering Professors (1990-1992)

Board of Directors, Association of Environmental Engineering Professors (1989-1992)

U.S. EPA Peer Review Panel (1988-present)

International Association for Water Quality Specialty Group on Anaerobic Digestion (1988-present)

Co-Chair, Program Committee for Society of Environmental Toxicology and Chemistry Annual Meeting (1988)

Vice Chair, American Society of Civil Engineers Committee on Design and Operation of Anaerobic Digesters (1981-86)

Selected Honors

Sigma Xi (1982)

Tau Beta Pi (1968)

Chi Epsilon (1968)

J. James R. Croes Medal from American Society of Civil Engineers for outstanding research paper of 1983 ("Modeling Toxicity in Methane Fermentation Systems")

College of Engineering Outstanding Undergraduate Teaching Award (Drexel University - 1984)

Hancher-Finkbine Medallion for Outstanding Professor at The University of Iowa (1989)

1991 Harrison Prescott Eddy Medal from Water Pollution Control Federation for outstanding research paper of 1990 ("Interaction Between Sulfate Reducers and Methanogens Fed Acetate and Propionate")

1995-96 University of Iowa Collegiate Teaching Award

Selected Publications

Parkin, G.F. and Speece, R.E., "Modeling Toxicity in Methane Fermentation Systems," 108 *J. Env. Eng. Div., ASCE* 515 (1982). *(received J. James R. Croes Medal from ASCE for this paper)*

Parkin, G.F., Speece, R.E., Yang, C.H.J., and Kocher, W.M., "The Response of Methane Fermentation Systems to Industrial Toxicants," 55 *J. Water Pollution Control Fed.* 44 (1983).

Parkin, G.F. and Speece, R.E., "Attached versus Suspended Growth Anaerobic Reactors: Response to Toxic Substances," 15 *Water Science and Tech.* 261 (1983).

Blum, D.J.W., Hergenroeder, R., Parkin, G.F., and Speece, R.E., "Anaerobic Treatment of Coal Conversion Wastewater Constituents: Biodegradability and Toxicity," 58 *J. Water Pollution Control Fed.* 122 (1986).

Speece, R.E., Parkin, G.F., and Bhattacharya, S.K., "Modeling Toxicity Response of Anaerobic Treatment," 18 *Water Science and Technology* 27-39 (1986).

Parkin, G.F. and Owen, W.F., "Fundamentals of Anaerobic Digestion of Wastewater Sludges," 112 *J. Env. Eng. Div., ASCE* 867-920 (Oct. 1986).

Bhattacharya, S.K. and Parkin, G.F., "Fate and Effect of Methylene Chloride and Formaldehyde in Methane Fermentation Systems," 60 *J. Water Pollution Control Fed.* 531-536 (1988).

Bhattacharya, S.K. and Parkin, G.F., "The Effect of Ammonia on Methane Fermentation Processes," 61 *J. Water Pollution Control Fed* 55-59 (1989).

Parkin, G.F., Lynch, N.A., Kuo, W.C., Van Keuren, E.L., and Bhattacharya, S.K., "Interaction Between Sulfate Reducers and Methanogens Fed Acetate and Propionate," 62 *Research Journal Water Pollution Control Federation* 780-788 (1990) *(received Harrison Prescott Eddy Medal from WPCF for this paper)*

Parkin, G.F., Sneve, M.A., and Loos, H., "Anaerobic Filter Treatment of Sulfate-Containing Wastewaters," 23 *Water Science and Technology* 1283-1291 (1991).

Wilber, G.G. and Parkin, G.F., "Transformation of Pesticides in Groundwater under Anaerobic Conditions," in *In-Situ and On-Site Bioreclamation* 385-402 (1991).

Hughes, J.B. and Parkin, G.F., "The Effect of Electron Donor on the Transformation of Chlorinated Aliphatics," in *In-Situ and On-Site Bioreclamation* 59-76 (1991).

Hughes, J.B. and Parkin, G.F., "The Effect of Mixtures of Xenobiotics and Primary Electron Donor on the Anaerobic Biotransformation of High Concentrations of Chlorinated Aliphatics," 26 *Water Science and Technology* 117-126 (1992).

Coyle, C.G., Parkin, G.F., and Gibson, D.T., "Aerobic, Phenol-Induced TCE Degradation in Completely Mixed, Continuous-Culture Reactors," 4 *Biodegradation* 59-69 (1993)

Maillacheruvu, K.Y., Parkin, G.F., Peng, C.Y., Kuo, W.C., Oonge, Z., and Lebduschka, V., "Sulfide Toxicity in Anaerobic Systems Fed Sulfate and Various Organics," 65 *Water Environment Research* 100-109 (1993).

Wilber, G.G. and Parkin, G.F., "Kinetics of Alachlor and Atrazine Biotransformation Under Various Electron Acceptor Conditions," 14 *J. Society for Environmental Toxicology and Chemistry* 237-244 (1995).

Weathers, L.J. and Parkin, G.F., "Metallic Iron-Enhanced Biotransformation of Carbon Tetrachloride and Chloroform Under Methanogenic Conditions," in R.E. Hinchee, A. Leeson, and L. Semprini, eds., *Bioremediation of Chlorinated Solvents*, 117-122 (1995).

Hughes, J.B. and Parkin, G.F., "Concentration Effects of Chlorinated Aliphatic Transformation Rates," 122 *J. of Environmental Engineering, ASCE* 92-98 (1996).

Hughes, J.B. and Parkin, G.F., "Individual Biotransformation Rates in Chlorinated Aliphatic Mixtures," 122 *J. of Environmental Engineering, ASCE* 99-106 (1996).

Kuo, W.C. and Parkin, G.F., "Characterization of Soluble Microbial Products from Anaerobic Treatment by Molecular Weight Distribution and Nickel-Chelating Properties," 30 *Water Research* 915-922 (1996).

Parkin, G.F., "Bioremediation: A Promising Technology but Not a Panacea" in F.B. Rudolph and L.V. McIntire, eds., *Biotechnology: Science, Engineering, and Ethical Challenges for the 21st Century* 113-128 (1996).

Kuo, W-C., Sneve, M.A., and Parkin, G.F., "Formation of Soluble Microbial Products During Anaerobic Treatment," 68 *Water Environment Research* 279-285 (1996).

Shurtliff, M., Parkin, G.F., Weathers, L.J., and Gibson, D.T., "Kinetics and Transformation Products of Aerobic, Phenol-Induced Trichloroethylene Degradation," 122 *J. of Environmental Engineering, ASCE* 581-589 (1996).

Vermace, M.E., Christensen, R.F., Parkin, G.F., and Alvarez, P.J.J., "Relationship Between the Concentration of Denitrifiers and *Pseudomonas* spp. in Soils: Implications for BTX Bioremediation," 30 *Water Research* 3139-3145 (1996).

Maillacheruvu, K.Y. and Parkin, G.F., "Kinetics of Growth, Substrate Utilization, and Sulfide Toxicity for Propionate, Acetate, and Hydrogen Utilizers in Anaerobic Systems," 68 *Water Environment Research* 1099-1106 (1996).

Weathers, L.J., Parkin, G.F., and Alvarez, P.J., "Utilization of Cathodic Hydrogen as Electron Donor for Chloroform Cometabolism by a Mixed, Methanogenic Culture," 31 *Environmental Science & Technology* 880-885 (1997).

Adamson, D.T. and Parkin, G.F., "Biotransformation of Mixtures of Carbon Tetrachloride, Perchloroethylene, and 1,1,1 Trichloroethane," in B.C. Alleman and A. Leeson, eds., *In Situ and On-Site Bioremediation: Volume 3*, 15-20 (1997).

Novak, P.J., Christ, S.C., and Parkin, G.F., "Kinetics of Alachlor Transformation and Identification of Metabolites Under Anaerobic Conditions," 31 *Water Research* 3107-3115 (1997).

Novak, P.J., Daniels, L., and Parkin, G.F., "Enhanced Dechlorination of Carbon Tetrachloride and Chloroform in the Presence of Elemental Iron and *Methanosarcina barkeri, Methanosarcina thermophila*, or *Methanosaeta concillii*," 32 *Environmental Science & Technology* 1438-1443 (1998).

Novak, P.J., Daniels, L., and Parkin, G.F., "Rapid Dechlorination of Carbon Tetrachloride and Chloroform by Extracellular Agents in Cultures of *Methanosarcina thermophila*," *Environmental Science & Technology*, (scheduled for 10/15/98 publication).

Adamson, D.T. and Parkin, G.F., "Biotransformation of Mixtures of Chlorinated Aliphatic Hydrocarbons by an Acetate-Grown, Methanogenic Culture," *Water Research* (in press).

Textbook

Sawyer, C.N., McCarty, P.L., and Parkin, G.F., *Chemistry for Environmental Engineering*, 4th edition, McGraw-Hill, New York (1994).

Education

B.S.C.E. with High Distinction, University of Iowa (1970)

M.S.C.E. University of Iowa (1970)

Ph.D. Stanford University (1977)

BRUCE E. RITTMANN

Employment

John Evans Professor and Area Coordinator of Environmental Health Engineering and with affiliate appointment in Chemical Engineering, Northwestern University (1992-present)

Full, Assoc., and Asst. Professor, Dept. of Civil Engineering, University of Illinois at Urbana-Champaign (1980-92)

Environmental Engineer, Sverdrup & Parcell and Assoc. (1974-75)

Professional Interests

Environmental biotechnology: Application of mathematical modeling, geochemistry, kinetics, and molecular biology for studying the interactions among microbiological, chemical, and physical processes in natural and engineered systems. Examples of systems studied include microbially driven fate of radionuclides in DOE co-contamination sites, adaptation of anaerobic communities to chlorinated solvents, acceleration of detoxification reactions by control of intracellular cofactors, biodegradation of petroleum hydrocarbons by microbial mats, water-quality changes in drinking water as it is distributed, biofiltration of gases contaminated with volatile organic contaminants, photobiocatalysis, and use of plasmid transfer to enhance biodegradation capacities of microbial communities.

Educational Activities

Supervised 13 PhD theses, 9 post-doctoral fellows, 8 visiting scholars, and many M. S. and undergraduate students.

Current mentoring: 9 graduate students, 1 post-doctoral fellow, and 2 undergraduate students.

Honors and Awards

Travel Fellowship, Japan Ministry of Education (Monbusho) (1997)

Fellow, American Association for the Advancement of Sciences (1996)

A.R.I. Clarke Prize, National Water Research Institute (1994)

Engineering-Science Award, AEEP (1979 and 1993)

Montgomery-Watson Award, AEEP (1992 and 1995)

Walter Huber Research Prize, ASCE (1990)

Academic Achievement Award, AWWA (1990)

CH2M-Hill Award, AEEP (1989 and 1995)

University Scholar Award, Univ. of Illinois (1987)

Xerox Faculty Research Award, Univ. of Illinois (1985)

Presidential Young Investigator Award, NSF (1984)

Chairman of Committee on In Situ Bioremediation, National Research Council (1992-93)

Board of Directors, Association of Environmental Engineering Professors (1988-92); President (1990-91)

Managing Editor, Biodegradation (1990-96); Editor-in-Chief (1996-2001)

Water Science and Technology Board, National Research Council (1991-97); Vice-Chairman (1994-97).

Chairman of Committee on Intrinsic Remediation, National Research Council (1997-99).

Major Research Accomplishments

Dr. Rittmann is an international leader in the fields of biofilm kinetics, biological treatment of drinking water, detoxification of hazardous organic chemicals, nitrification, the use of molecular techniques to study microbial communities in natural and engineered processes, bioremediation, and mathematical modeling that couples microbial kinetics to geochemical processes. His standing is recognized by the numerous research prizes, by his selection to be a chairman of two National Research Council committees, and Editor-in-Chief of Biodegradation.

Significant Publications (total number is 225)

Sáez, P. B. and B. E. Rittmann, "Biodegradation kinetics of a mixture containing a primary substrate (phenol) and an inhibitory co-metabolite (4-chlorophenol)," 4 *Biodegradation* 3-23 (1993)

Raskin, L., L. K. Poulson, D. R. Noguera, B. E. Rittmann, and D. A. Stahl, "Quantification of methanogenic groups in anaerobic biological reactors using oligonucleotide

probe hybridizations," 60 *Appl. Environ. Microb.* 1232-1240 (1994).

Teske, A., E. Alm, J. M. Regan, S. Toze, B. E. Rittmann, and D. A. Stahl, "Evolutionary relationships among ammonia- and nitrite-oxidizing bacteria," 176 *J. Bacteriology* 6623-6630 (1994).

Rittmann, B. E., "Transformation of organic micropollutants by biological processes," in *Quality and Treatment of Drinking Water*, J. Hrubec, Ed., 5B *The Handbook of Environmental Chemistry* 31-60 (1995).

Malmstead, M. J., F. Brockman, A. J. Valocchi, and B. E. Rittmann, "Modeling biofilm biodegradation requiring cosubstrates: the quinoline example," 31(1) *Water Sci. Technol.* 71-84 (1995)

Bae, W. and B. E. Rittmann, "Accelerating the rate of cometabolic degradations requiring an intracellular electron source--model and biofilm application," 31(1) *Water Sci. Technol.* 29-39 (1995)

Wrenn, B. A. and B. E. Rittmann, "Evaluation of a mathematical model for the effects of primary substrates on reductive dehalogenation kinetics," 7 *Biodegradation* 49-64 (1996).

Smets, B. F., B. E. Rittmann, and D. A. Stahl, "Quantification of the effect of substrate concentration on the conjugal transfer rate of the TOL plasmid in short-term batch mating experiments," 21 *Letters in Applied Microbiology* 167-172 (1996)

Guschin, D. Y., B. K. Mobarry, D. Proudnikov, D. A. Stahl, B. E. Rittmann, and A. D. Mirzabekov, "Oligonucleotide microchips as genesensors for determinative and environmental studies in microbiology," 63 *Appl. Environ. Microb.* 2397-2402 (1997)

Brusseau, G. A., B. E. Rittmann, and D. A. Stahl, "Addressing the microbial ecology of marine biofilms," in K. E. Cooksey, ed., *Molecular Approaches to the Study of the Oceans* 449-470 (1997).

Yu, H. and B. E. Rittmann, "Predicting bed expansion and phase holdups for three-phase, fluidized-bed reactors with and without biofilm," 31 *Water Research* 2604-2616 (1997).

Education

Ph.D. Environmental Engineering, Stanford University (1979)

M.S. Environmental Engineering, Washington University (1974)

B. S. Civil Engineering, Washington University (1974)

YARON M. STERNBERG, Ph.D.

PROFESSIONAL APPOINTMENTS

Professor of Civil Engineering at the University of Maryland

President and founding Principal of Signum Environmental, Inc., Rockville, Maryland

Former principal, Environ Corporation

Former Director, International Rural Water Resources Development Laboratory, University of Maryland

Former Member, Environmental Institute for Waste Management Studies, University of Alabama.

Former Research Scholar, Office of Water Research and Technology, U.S. Department of the Interior

Former Associate Professor of Civil Engineering, University of Maryland

Former Assistant and Associate Professor of Geology, Indiana University, Bloomington, Indiana

PROFESSIONAL EXPERIENCE

Over thirty years of experience in the areas of ground water hydrology and waste disposal, with particular emphasis on ground water monitoring and the movement of pollutants.

Dr. Sternberg has directed remedial investigations at industrial and hazardous waste sites, evaluated and developed ground water remediation programs, prepared environmental liability assessments of numerous indus-

trial facilities, and provided expert testimony in legal proceedings.

PROFESSIONAL MEMBERSHIPS

Member, American Society of Civil Engineers.

Member, American Geophysical Union.

Member, National Ground Water Association.

PUBLICATIONS

Sternberg, Yaron M. and Verne H. Scott, "The Hele-Shaw Model–A Research Device in Ground Water Studies," 2:4 *Ground Water* 33-37 (October 1964)

Sternberg, Yaron M. and Verne H. Scott, "Mutual Interference of Water Wells," 93 *J. of the Hydraulics Division, ASCE*, No. HY4, pp. 169-181 (July 1967)

Sternberg, Yaron M. Transmissibility Determination from Variable Discharge Pumping Tests, 5:4 *Ground Water* 27-29 (October 1967)

Sternberg, Yaron M., "Analysis of Sprinkler Irrigation Losses, 93 *J. of the Irrigation and Drainage Division, ASCE*, No. IR4, pp. 111-124. (December 1967)

Sternberg, Yaron M., "Simplified Solution for Decreasing Flow to Wells," 94 *J. of the Hydraulics Division, ASCE*, HY1, pp. 177-180. (January 1968)

Sternberg, Yaron M. and Allen F. Agnew. Hydrology of Surface Mining - A Case Study, *Water Resources Research*, Volume 4, No. 2, April, 1968, pp. 363-368.

Sternberg, Yaron M., "Nonsteady Two-Layer Radial Flow to Wells," International Association of Scientific Hydrology, Publication No. 77, pp. 329-342 (1968).

Meinschein, W.G., Yaron M. Sternberg, and Ronald W. Klusman, "Origins of Natural Gas and Petroleum," 220 *Nature* 1185-1189 (December 1968)

Sternberg, Yaron M., "Some Approximate Solutions for Radial Flow Problems," 7 *J. of Hydrology* 158-166 (1969)

Sternberg, Yaron M., "Flow to Wells in the Presence of Radial Discontinuities," 7:6 *Ground Water* 158-166 (1969).

Lewis, Lawrence A. and Yaron M. Sternberg, "Changes in the Configuration of Stream Channels Resulting from the Construction of Dams," 80 *Proceedings of the Indiana Academy of Sciences* 351-355 (1971)

Sternberg, Yaron M., "Parameter Estimation for Aquifer Evaluation," 7:3 *Water Resources Bulletin* 447-456 (1971).

Thomere, Roland, Paul E. Potter and Yaron M. Sternberg. Permeability, Cementation and Grain Size: A Deductive Inquiry, Society of Petroleum Engineering Paper No. 3606, October, 1971.

Sternberg, Yaron M., "Well Efficiency and the Skin Effect," 99 *Journal of the Irrigation and Drainage Division, ASCE*, No. IR2, 203-206 (June 1973).

Sternberg, Yaron M. Efficiency of Partially Penetrating Wells, 11:4 *Ground Water* (1973)

Sternberg, Yaron M., "Theory and Application of the Skin Effect Concept to Ground Water Wells," 2 *Proceedings of the International Symposium on Development of Ground Water Resources, Madras, India* 23-32 (Nov. 1973).

Tagamets, T. and Yaron M. Sternberg, "A Predictor-Corrector Method for Solving the Convection-Dispersion Equation for Adsorption in Porous Media," 10:5 *Water Resources Research* 1003-1011 (1974)

Moynahan, T. and Yaron M. Sternberg. Effects on Highway Subdrainage of Gradation and Direction of Flow Within a Densely Grated Base Course Material, Transportation Research Board, No. 497, pp. 50-59, 1974.

Sternberg, Yaron M., "An Assessment of Potential Ground Water Pollution Associated with Land Application of Domestic Effluent in Drinking Water," in Quality Enhancement Through Source Protection, R. B. Pojasek, ed., Ann Arbor Science, Ann Arbor, Michigan, 1977, pp. 235-255.

Sternberg, Yaron M. Testing of Wood Bearings for Hand Pumps, International Bank for Reconstruction and Development, Report No. RES 13, PUD, Feb., 1978.

Sternberg, Yaron M. and Robert Knight, Development of PVC Well Screens, Local Fabrication in Developing Countries, International Bank for Reconstruction and Development, Report No. RES 16, PUD, March, 1978.

Sternberg, Yaron M., *Final Report on the Development and Testing of the Robo Valve*, AID Contract ta-c-1461 (June 1978)

Sternberg, Yaron M., *Final Report on the Development of the Robo Meter*, AID Contract ta-c-1460 (January 1979)

Allison, S.V., Yaron M. Sternberg and R. Knight, "Well Casings and Single Stalks of Bamboo and a Manually Operated Slotter," 5(1) *Appropriate Technology* (1978)

Sternberg, Yaron M., R. Knight and R. Middleton, "PVC Well Screens for Local Manufacture in Developing Countries," 7(1) *Appropriate Technology* (1980).

Sternberg, Yaron M. and R. Knight, *Final Report on the Development of the Broached Roboscreen*, AID Contract DPSE-C-0038 (1980).

Sternberg, Yaron M., M. Silver and S.V. Allison, "Flow Meter for Measuring Discharge of Small Pumps," 9:1 *Appropriate Technology* (1982)

El-Damak, R.J., Yaron M. Sternberg, and R.M. Ragan, "Soil Moisture Root Water Uptake Model Depending on Transpiration Rate," Hydrologic Research series, Remote Systems Sensing Laboratory, University of Maryland, College Park, MD. (1984)

Yim, C.S., and Yaron M. Sternberg, *Laboratory tests of stormwater management infiltration structures (SWMIS)*. FHWA/MD - 84/02, AW 084-288-046. Maryland Department of Transportation (1984).

Sternberg, Yaron M., Mathematical Models of Contaminant Transport in Ground Water, Environmental Institute for Waste Management Studies, University of Alabama, April 1985.

Schlesinger, J.S., R.J. Machado, S.H. Youngren, C. Baynes, and Yaron M. Sternberg, "Application of Air Model in a Risk Assessment, in American Society of Civil Engineers, *Proceedings of the 1987 Specialty Conference: Environmental Engineering* (1987)

Yim, C.S., and Yaron M. Sternberg, *Development and testing of granular filter design criteria for stormwater management (SWMIS). FHWA 1MD - 87/01, AW 087-288-309*. Maryland Department of Transportation (1987).

Yim, C.S., and Yaron M. Sternberg, "Practical solution for estimating time required for aquifer restoration," in *Proceedings of Hazardous Materials Control - Great Lakes '90 Conference* (1990)

Yim, C.S., Yaron M. Sternberg, and M.F.N. Mohsen, "Practical Solution for estimating time required for aquifer restoration: An update," in *Proceedings of Hazardous Materials Control* (1991)

Dielman, S.A., Yaron M. Sternberg, Charles F. McLane, "Design and Evaluation of a Ground Water Monitoring Well Network," in *Proceedings of the Superfund XIV Conference and Exhibition* (1993)

EDUCATION

Ph.D., Water Resources Engineering (Ground Water Hydrology), University of California (1965)

M.S., Water Resources Engineering (Irrigation and Drainage), University of California (1963)

B.S., Agricultural Engineering (Soil and Water), University of Illinois (1961)

DONALD W. VANNOY

Professional Appointments

Professor of Civil Engineering, University of Maryland (1974-present)

President, Vannoy & Associates, Silver Spring, MD. Served as Chief Technical Advisor to Governments of India and Malawi, United States, U.S. State Department, and Lloyds of London. Conducted over 300 structural evaluations and project failure analyses.

Professional Societies and Registration

Registered Professional Engineer (Maryland, West Virginia, and Washington, DC)

American Society of Civil Engineers

American Concrete Institute

National Academy of Sciences

American Society of Testing and Materials

Professional Committees and Organizations

Maryland Section, American Society of Civil Engineers: Board of Directors (1991-present); President (1989-90); Vice-President (1988-89); Board of Directors (1986-88)

Steel Bridge Committee, American Society of Civil Engineers (Chairman, 1985-89)

Tau Beta Pi (Board of Directors, 1982-86)

Honors, Awards and Honorary Societies

1991 Civil Engineer of the Year, Maryland Section, American Society of Civil Engineers and National Society of Professional Engineers

Judge for the 1988 Engineering Excellence Competition

1986 Special Service Award by Tau Beta Pi

1983 Special Award by *Engineering News-Record*

Outstanding Teacher Award for Civil Engineering—1984 and 1990

Tau Beta Pi

Phi Kappa Phi

Sigma Xi

Publications

Contributions to three books

28 Refereed Papers

20 Technical Reports

50 Talks and Seminars

Education

Ph.D. in Civil Engineering, University of Virginia (1975)

M.S., University of Virginia (1971)

B.S.C.E., West Virginia Institute of Technology (1970)

DAVID L. WAGGER

Professional Experience

Senior Associate, Signum Environmental, Inc., Rockville, MD. Analyses and modeling of the environmental aspects of industrial processes, particularly those in energy- and chemical-intensive industries.

Former A.A.A.S. Diplomacy Fellow, U.S. Agency for International Development (A.I.D.). He worked on a range of energy and environmental issues affecting developing countries for A.I.D. He also participated in preparing for international-treaty negotiations at the U.S. State Department and in reviewing energy-sector loans for the Office of the U.S. Executive Director at the International Bank for Reconstruction and Development (World Bank).

Former Diplomacy Fellow, American Association for the Advancement of Science (A.A.A.S.), U.S. Agency for International Development

Former Research Assistant, Massachusetts Institute of Technology, Department of Chemical Engineering.

Former Research Fellow, Fannie and John Hertz Foundation, Massachusetts Institute of Technology.

Former Engineering Cooperative Intern, National Bureau of Standards (now National Institutes of Standards and Technology).

Professional Memberships

Member, American Chemical Society—Environmental Chemistry Division, Chemistry & the Law Division

Member, American Institute of Chemical Engineers—Environmental Section

Member, American Association for the Advancement of Science

Member, Sigma Xi

Publications

Virk, P. S. and D. L. Wagger, "Aspects of Mechanisms in Type B Drag Reduction" in A. Gyr, ed., *IUTAM Symposium Zurich/Switzerland 1989: Structure of Turbulence and Drag Reduction* 201-213 (1990)

Education

Ph.D., Chemical Engineering (Non-Newtonian, Turbulent Fluid Mechanics), Massachusetts Institute of Technology (1992)

B.S., Chemical Engineering, University of California at Berkeley (1985)

J. CHRISTOPHER WILT

Employment

Director, Boeing Nacelle Components Program, Commercial Aircraft Division, Northrop Grumman

Professional Memberships and Honors

Registered Professional Engineer (Texas)

Member, Tau Beta Pi

Associate Fellow, American Institute of Aeronautics and Astronautics

Congressional Fellow, National Society of Professional Engineers in conjunction with American Association for the Advancement of Science (1986)

Listed in *Who's Who in Science & Engineering* (2d ed.)

Education

Graduate, Defense Systems Management College (1990)

M.B.A., Southern Methodist University (1983)

M.S. in Mechanical Engineering, Southern Methodist University (1983)

B.S. in Aerospace Engineering, University of Florida (1976)

M. GORDON WOLMAN

Professional Appointments

The Johns Hopkins University:
- Professor of Geography (1968-present)
- Professor, Joint Appointment, Department of Environmental Health Sciences (1997-98)
- Interim Provost and Vice President for Academic Affairs (1990-91)
- Interim Provost (1987)
- Chairman, Department of Geography and Environmental Engineering (1970-90)
- B. Howell Griswold, Jr. Professor of Geography and International Affairs (1975)
- Chairman, Isaiah Bowman Department of Geography (1958-68)
- Associate Professor, Department of Geography (1958-62)

U.S. Geological Survey, Hydrologist, 1951-70; part-time (1958-78)

Vista Lecturer, University of Washington (1995)

Chester Kisiel Lecturer, Department of Hydrology and Water Resources, University of Arizona (April 1994)

Snider Visiting Lecturer, University of Toronto (1986)

Ralph H. Brown Day Lecturer, University of Minnesota (1985)

Ida Beam Visiting Professor, University of Iowa (1982)

Visiting Professor, University of Virginia (1980)

Visiting Professor, University of Maryland (1977)

Visiting Lecturer, University of London (1973)

Visiting Lecturer, University of Wisconsin (1968)

Visiting Lecturer, University of Texas (1965)

Teaching position, U.S. Department of Agriculture, Agricultural Research Service (1965)

Professional Societies

Sigma Xi

Phi Beta Kappa (1971)

Geological Society of America, President (1984)

American Geophysical Union, President, Section on Hydrology (1970-72)

Agricultural History Society

American Society of Civil Engineers

Geological Society of Washington

American Geographical Society (Councilor, 1966-70)

Association of American Geographers

Soil Conservation Society

Awards

American Geological Institute, Medal in memory of Ian Campbell (1997)

Rachel Carson Award, Chesapeake Appreciation, Inc. (1995)

D.L. Linton Award, British Geomorhpological Research Group (1994)

Distinguished Career Award, Association of American Geographers, Geomorphology Specialty Group (1993)

Cullum Geographical Medal, Council of the American Geographical Society (1989)

Distinguished Mentor, National Council for Geographic Education (1989)

John Wesley Powell Award, U.S. Geological Survey (1989)

Member, National Academy of Sciences (1988)

Fellow, American Association for the Advancement of Science (1984)

Fellow, American Academy of Arts and Sciences (1981)

Meritorious Contribution Award, Association of American Geographers (1972)

Award of the Joint Engineering and Architects Societies of Washington, DC, to outstanding young scientists in the Washington area (1957)

Professional Organizations and Positions

Member, Environmental Advisory Committee, Westinghouse Savannah River Company (1996-present)

Member, Advisory Committee, Oak Ridge National Laboratory (1996-present)

Chairman, Steering Committee, Population and Land Use Studies, National Academies of Science, U.S., China and India

Member, Board on Sustainability, National Research Council (1994-present)

Chair, Commission on Geosciences, Environment, and Resources, National Research Council (1990-96)

Chairman, Governor's Committee on the Role of the State of Maryland in Fisheries Management (1990-91)

Speaker and Advisor, U.S. Geological Survey, Surficial Processes Workshop (1990)

Chairman, Geological Society of America, Committee to select Donath Medal Winner (1990)

Member, Advisory Committee, National Water-Quality Networks, U.S. Geological Survey (1989-present)

National Center for Geographic Information and Analysis, Member, Board of Directors (1988-91)

Chair, Committee to Review State Policy for Funding Maryland's Chesapeake Bay Fisheries, State of Maryland (1989-93)

Member, National Academy of Sciences/National Research Council Committee on Global Ecology reporting to the U.S. and U.S.S.R. governments (1989-91)

The Geological Society of America: Vice President (1982); President (1984)

National Academy of Sciences, NRC, Chairman, Committee Advisory to the U.S. Geological Survey (1982-83)

Moderator, Potomac River Low Flow Allocation Agreement Between the State of Maryland, the Commonwealth of Virginia, the District of Columbia, and the U.S. Army Corps of Engineers (1980-present)

International Council of Scientific Unions, Scientific Committee on Problems of the Environment (SCOPE) (1979-present)

World Health Organization, Independent Commission on the Future of the Onchocerciasis Control Programme in West Africa (1978-81)

National Research Council, Assembly of Engineering, Board (1979-80)

Resources for the Future: Board of Directors (1978-87); Chairman of the Board (1979-87)

Energy: The Next Twenty Years, Resources for the Future/Ford Foundation Energy Policy Study (1978-79)

Maryland Geological Survey Commission (1974-present); Chairman (1974-present)

Geological Society of America, Council (1976-78)

National Research Council, Environmental Studies Board (1974-77)

National Academy of Sciences, National Committee on Water Quality Policy (1974-77)

National Academy of Sciences, Committee on Mineral Resources and the Environment (1973-75)

National Academy of Sciences Executive Committee, Earth Sciences Division (1972-74)

Editorial Board, *Science* (1973-74)

National Academy of Sciences/National Academy of Engineering, Committee on International Environmental Programs (1970-72)

National Academy of Sciences/National Academy of Engineering, Environmental Studies Board, Steering Committee, Jamaica Bay Study (1970-71)

National Research Council, Committee on Geological Sciences (1969-72)

International Association of Scientific Hydrology, President, Commission on Land Erosion (1968)

Committee on Space Programs for Earth Observations Advisory to the U.S. Geological Survey (1966, 1970)

American Geophysical Union, President, Section on Hydrology (1970-72)

Editorial Advisory Board, *Geografiska Annaler* (1970-present)

Editorial Advisory Board, *Journal of Hydrology* (1969-76)

Office of Water Resources Research, Special Advisory Panel (1967)

American Geographical Society, Councilor (1966-70)

American Institute of Architects Task Force on Potomac Planning to the Secretary of the Interior (1964-67)

Subcommittee on Air and Water Pollution of the Maryland Scenic Beauty Commission (1965)

U.S. National Committee for the International Hydrological Decade (1965-67)

Scientific Advisory Council, Maryland Academy of Sciences (1965-67)

National Academy of Sciences, National Research Council Committee on Water (1965-68)

National Research Council, Executive Committee, Division of Earth Sciences (1966-68)

National Academy of Sciences, Ad Hoc Committee on Geography (1964-65)

Committee on Status and Needs in Hydrology, American Geophysical Union (1964)

Universities Council on Water Resources, Executive Board (1963-65)

Committee on Geography, Advisory to the Office of Naval Research (1961-64)

Subcommittee on Sedimentation, American Geophysical Union, Chairman (1960-62)

Representative Publications

"Water quality trends in the nation's rivers," with Smith and Alexander, 235 *Science* 607-15 (1987)

H. Landsberg, ed., *Energy: The Next Twenty Years* (Ford Foundation Energy Study Group, 1979)

"Floods and people: A geological perspective," in Geological Society of America, *Report of the Committee on Geology & Public Policy* (1978)

"Relative Scales of Effectiveness of Climate in Watershed Geomorphology," with Ran Gerson, 3 *Earth Surface Processes* 189-208 (1978)

"Crisis and Catastrophe in Water-Resources Policy," in U.S. Geological Survey Prof. Paper 921, *Earth Science in the Public Service* 17-27 (1974)

"The nation's rivers," 174 *Science* 905-18 (1971)

"Cycle of sedimentation and erosion in urban river channels," 49 *Geografiska Annaler* Ser. A:385-95 (1967)

Fluvial Processes in Geomorphology (with L.B. Leopold and J.P. Miller) (1964)

Education

Ph.D., Geology, Harvard University (1953)

M.A., Geology, Harvard University (1951)

B.A. with honor, The Johns Hopkins University (1949)

APPENDIX B

Selected List of Peer-Reviewed Engineering Journals*

A I CH E Equipment Testing Procedures Series
A I CH E Journal
A I CH E M I Modular Instruction. Series A: Process Control
A I CH E M I Modular Instruction. Series C: Transport
A I CH E M I Modular Instruction. Series D: Thermodynamics
A I CH E M I Modular Instruction. Series E: Kinetics
A I CH E M I Modular Instruction. Series F: Material and Energy Balances
A I CH E M I Modular Instruction. Series G: Design of Equipment
A I CH E Symposium Series
A S A E Transactions. Information and Electrical Technologies - Emerging Technologies
A S A E Transactions. Structures and Environment
Advanced Cement Based Materials
Advances in Chemical Engineering
Advances in Imaging and Electron Physics
American Society for Testing and Materials. Data Series Publications
American Society for Testing and Materials. Five-Year Index to A S T M Technical Papers and Reports
American Society for Testing and Materials. Special

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* Source: 2 *Ulrich's International Periodicals Directory* 2708-904 (36th ed. 1998).

Technical Publications
Annual Allerton Conference on Communication, Control and Computing
Applied Mechanics Reviews
Association of Asphalt Paving Technologists. Proceedings
Atomization and Sprays
Brown Boveri Symposia. Proceedings
Chemical and Petroleum Engineering
Chemical Engineering
Chemical Engineering Education
Civil Engineering Practice
Color Research and Application
Combustion and Flame
Combustion, Explosion, and Shock Waves
Computer Applications in Engineering Education
Cornell Biennial Electrical Engineering Conference
Corrosion
Corrosion Abstracts
Electric Machines and Power Systems
Electromagnetics
Electromechanical Bench Reference
Electronic Journal of Geotechnical Engineering
Ergonomics in Design
Experimental Mechanics
Experimental Techniques
Experimental Thermal and Fluid Science
Fluid Power Journal
Fundamental Materials Research
Geotechnical Testing Journal
Gongneng Gaofenzi Xuebao/Journal of Functional Polymers

Heat Transfer Engineering
Human Factors
Human Factors and Ergonomics Society Annual Meeting. Proceedings
Human Factors in Ergonomics and Manufacturing
Hydrotechnical Construction
In Situ
International Applied Mechanics
International Journal of Damage Mechanics
International Journal of Flexible Manufacturing Systems
International Journal of Microwave and Millimeter-Wave Computer Aided Engineering
International Journal of Offshore and Polar Engineering
International Society for Terrain-Vehicle Systems. Proceedings of International Conference
Journal of Aerospace Engineering
Journal of Applied Mechanics and Technical Physics
Journal of Applied Polymer Science. Symposia
Journal of Cold Regions Engineering
Journal of Composite Materials
Journal of Composites Technology and Research
Journal of Dynamic Systems, Measurement and Control
Journal of Dynamical and Control Systems
Journal of Electronic Testing
Journal of Engineering Materials and Technology
Journal of Engineering Mechanics
Journal of Engineering Technology
Journal of Flow Visualization and Image Processing
Journal of Fluids Engineering
Journal of Geotechnical Engineering
Journal of Heat Transfer

Journal of Hydraulic Engineering (New York)
Journal of Infrastructure Systems
Journal of Irrigation and Drainage
Journal of Materials Engineering and Performance
Journal of Materials in Civil Engineering: Properties, Applications, Durability
Journal of Materials Synthesis and Processing
Journal of Mechanical Design
Journal of Microelectronic Systems Integration
Journal of Microwave Power and Electromagnetic Energy
Journal of Nondestructive Evaluation
Journal of Offshore Mechanics and Arctic Engineering
Journal of Professional Issues in Engineering and Practice
Journal of Reinforced Plastics and Composites
Journal of Russian Laser Research
Journal of Testing and Evaluation
Journal of Thermal Insulation and Building Envelopes
Journal of Thermal Stresses
Journal of Turbomachinery
Journal of Vibration and Acoustics
Journal of Water Resources Planning and Management
Journal of Women and Minorities in Science and Engineering
Lubrication Engineering
M R S Internet Journal of Nitride Semiconductor Research
Magnetohydrodynamics
Magnets in Your Future
Massachusetts Institute of Technology. Research Laboratory of Electronics. R L E Progress Report
Materials & Manufacturing Processes
Materials Evaluation

Materials Science
Materials Science Research
Mechanical Engineering
Mechanical Engineering Series
Mechanics of Composite Materials
Mechanics of Structures and Machines
Microcomputers in Civil Engineering
Microwave Journal (International Edition)
Missouri. Division of Geological Survey and Water Resources. Engineering Geology Series
Monographs in Physical Measurement
Multiphase Science and Technology
N E T A World
Naval Engineers Journal
Noise Control Engineering Journal
Notre Dame Technical Review
Numerical Heat Transfer Part A: Applications
Numerical Heat Transfer Part B: Fundamentals
Oceans. Conference Record
Ozone: Science and Engineering
Particulate Science and Technology
Petroleum Science and Technology
Plasma Chemistry & Plasma Processing
Polymer Engineering and Science
Polymer Reaction Engineering
Power (New York)
Precision Engineering
Previews of Heat and Mass Transfer
Pyrotechnic Literature Series
Pyrotechnic Reference Series
Pyrotechnica

Quality Engineering
Quality Progress
Research in Nondestructive Evaluation
Reviews in Engineering Geology
Sea Technology
Society for Information Display. Symposium Digest
Soil Mechanics and Foundation Engineering
Solid Fuel Chemistry
Springs
Strength of Materials
T A P P I Engineering Conference Proceedings (Year)
Technometrics
Treatise on Materials Science & Technology
Trenchless Technology
Tribology Transactions
Turbomachinery International
University of Illinois at Urbana-Champaign. Engineering Experiment Station. Summary of Engineering Research